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TABLE OF CONTENTS

LEADING ARTICLES: Page

German Four-Cylinder Balanced Compound Locomotive, with Superheater, at the St. Louis Exhibition (illustrated) 469
Maintenance of Machinery in Merchant Ships; Robert Haig, M. Soc. N. A. & M. E. 470
The Powell Process of Preserving Timber 473
The Progressive Sinking of the Ground Water Level and Artificial Ground Water Supplies (illustrated); Prof. J. Gustav Richert 474
The Shone System of Fan Ventilation of Sewers at Darley Abbey and at Leicester, England 475
An Ingenious and Effective Air-Lift Pump (illustrated) 476
Simple Methods in Warship Design a Necessity; Geo. W. Dickie, M. Soc. N. A. & M. E. 477
Designs for Bascule Bridges Without Tail Pits (illustrated) 480
Annual Meeting of the Society of Naval Architects and Marine Engineers 480
Vision of Railway Enginemen and Firemen in Relation to Signaling; Nelson M. Black 483

Page

High Duty from a Direct-Acting Pumping Engine Without Fly-Wheel or High-Duty Attachment (illustrated) 484
Data in Regard to the Present Low-Water Period in the Southeastern States; M. R. Hall 487
A Reinforced Concrete Girder Bridge With Open Webs (illustrated) 488

EDITORIAL COMMENT.—The Call for Bids for the New York Barge Canal Work.—The Origin of the Cantilever Bridge.—Growth of Electric Interurban Railways in Illinois 485

EDITORIALS:

Specifications for a Sewerage System 485
Sewer Ventilation by Fans and by Natural Means 486

LETTERS TO THE EDITOR.—Upward Wind Pressures; C. A. P. Turner.—Concerning the Merit System; D. H. R.—Formulas for Crown Thickness of Masonry Arches; Daniel B. Luten 487

ENGINEERING NEWS OF THE WEEK 488

GERMAN FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE, WITH SUPERHEATER, AT THE ST. LOUIS EXHIBITION.

The extensive locomotive exhibit at the St. Louis exhibition includes three foreign engines of special interest: 1, The German four-cylinder balanced compound locomotive; 2, The German three-cylinder high-speed locomotive; 3, The French four-cylinder balanced compound locomotive. The second and third of these were described in our issues of March 31 and May 12, 1904.

The German four-cylinder balanced-compound engine is of the Atlantic, or 4-4-2 type, and is one of 30 engines for the Prussian State Railways, some of which are in service and others under construction. The St. Louis engine was in regular fast passenger service for a short time on the Hanover Division, and is said to have been able to haul 300-ton trains of vestibuled cars at a continuously maintained speed of 62 miles an hour on the level and 50 miles an hour on ascending grades of 0.5%. Similar engines are said to have shown remarkably smooth running at speeds up to 80 miles an hour. The engine is notable not only for its system of compounding, but for the fact of its being fitted with a superheater, to which we shall refer more fully later. The compounding is on the Von Borries system, in which all the cylinders are in a row at the smokebox, and are all connected to the front driving axle. Each cylinder has its own valve, but the valves of each pair of cylinders are operated from a single valve gear. A view of the engine is given in Fig. 1.

The high pressure cylinders are inside, and each pair of cylinders, with the valve chambers, is formed on one casting. An interesting feature of the design is that the engine has bar frames at the front end, carrying the cylinders, while the ordinary European type of plate frames is used back of the cylinders. The driving springs are placed beneath the boxes. The engine has a wide firebox with flat crown sheet and flaring sides, as shown in Fig. 2. There are two fire doors, operated by lever handles. The smokebox and front-end arrangement are shown in Fig. 3, and it will be seen that the smokebox is of unusual length, but with the smokestack placed nearer to the front end than to the tube plate, which is the reverse of American practice with long smokeboxes. The spark-arrester consists of a cone of wire netting extending from the exhaust nozzle to the smokestack, which extends down into the smokebox.

The two cranks on each side are set at 180° with each other; and each crank is at 90° with the corresponding crank on the other side. With this arrangement the weights of the reciprocating parts are almost balanced and only a slight counterweighting is required in the wheels. Piston valves with inside admission are used for the high-pressure cylinders and balanced slide valves for the low pressure cylinders. The valve gear is of the Heusinger-Walschaert type (as modified by Mr. Von Borries), operated from eccentrics on the axle instead of from outside return cranks. As already noted the two valves on each side are operated from a single valve gear, and the arrangement is clearly shown in Figs. 4 and 5. The eccentric rod A is attached to the link B, which is controlled by the reach rod C. From the link extends the valve rod D, attached to the vertical lever E, which is in turn connected to the crosshead by the horizontal rod F. Pivoted to the lever E is the rod G, operating the valve stem H, of the high pressure cylinder. Pivoted to the top of the vertical lever E, are the arms J at one end of the rocker shaft K. A similar pair of arms L, is pivoted to the vertical lever M, which corresponds to the lever E and is connected to the low pressure crosshead by the rod N. Attached to the top of lever M, is the rod O, connected to the valve stem B, of the low pressure cylinder. The cut-off cannot be varied independently in the high and low pressure cylinders, but the gear is so arranged that the high pressure valve is always in advance of the low pressure valve, thus giving a shorter cut-off in the high pressure cylinder. Thus with cut-offs of 0.3% or 0.5% in the high-pressure, the cut-off in the low pressure cylinders will be 0.5% or 0.7% respectively.

Ease in starting the engine is ensured by the admission of live steam to the low pressure cylinders, this admission being governed automatically by the throttle. For lubricating the pistons and valves there is a Friedmann oil pump, with eight outlets; there are two pipes to each high-pressure valve, one to each low-pressure valve, and one to each cylinder. This pump is worked by a connection from the valve rod, so that the travel of the valve regulates the quantity of oil delivered. Each lubricating pipe has a small check valve to keep the pipe always full of oil.

The tractive power (T) of this four-cylinder compound locomotive is 16,083 lbs., being calculated by the following formula:

$$\frac{C^2 \times S \times \frac{2}{3} P}{D} + \frac{B^2 \times S \times \frac{1}{4} P}{D} = T.$$

C = diameter of h. p. cylinder ..... $14^{3}/_{16}$ ins.
B = " " l. p. " ..... $22^{1}/_{16}$ "
S = stroke of piston ..... $25^{9}/_{16}$ "
P = boiler pressure ..... 200 lbs.
D = diameter of driving wheels ..... 6 ft. $5^{15}/_{16}$ ins.

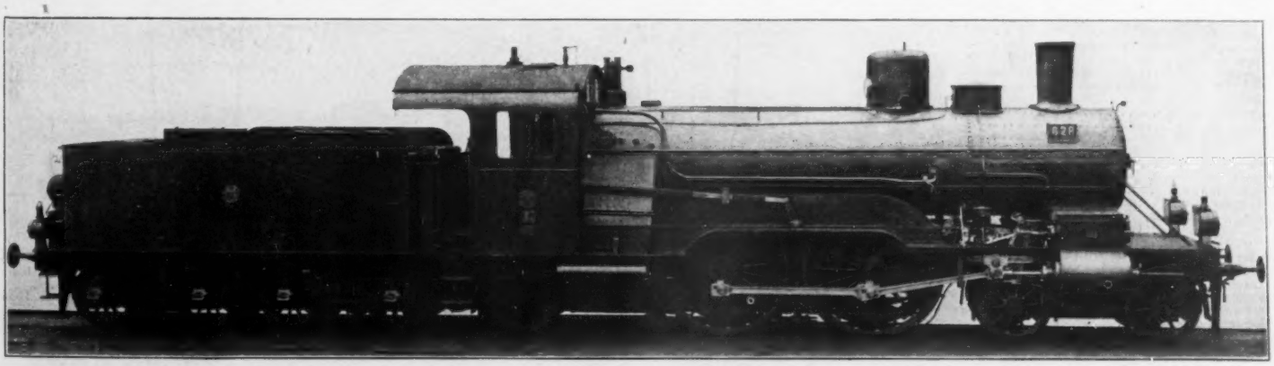

FIG. 1. FOUR-CYLINDER BALANCED COMPOUND PASSENGER LOCOMOTIVE (VON BORRIES SYSTEM) FOR THE PRUSSIAN STATE RAILWAYS; ST. LOUIS EXHIBITION.

Hanoversche Maschinenbau-Actien-Gesellschaft, Linden, (Near Hanover), Germany, Builders.

The superheater is of the Pielock system, which is in use on a number of railways in Germany, the Southern Railway of Italy, and the Hungarian State Railways. Its construction is shown in Figs. 6 and 7. It consists of a rectangular box with tube plates corresponding to those of the boiler, the box being set in the boiler barrel so that the tubes pass through it. It is placed at such a distance from the firebox as to ensure that the tubes will not be overheated. Vertical baffle plates between the rows of tubes cause the steam to pursue a circuitous course, passing up and down between the tubes. The steam from the dome passes down the open pipe A to the left hand chamber B, of the superheater, Fig. 6; it then traverses the several chambers, as shown by the arrows, until it

reaches the right hand chamber C. From this it passes up through the pipe D to the chamber enclosing the throttle valve, from which it enters the steam pipe E.

The boiler tubes are first set in place in the superheater, and then placed in the boiler, the smokebox tube plate being left off for this purpose. The tubes are then expanded into the firebox tube plate, the superheater plates (for which a special mandril is used), and finally in the smokebox tube plate. A blow-off cock extends from the bottom of the superheater through the boiler, so that it can be ascertained if the superheater is watertight. A gage on the dome shows the degree of superheat of steam in the throttle valve chamber.

On locomotives with piston valves, a superheating of 350° C. may be used, but it is recommended that 280° C. should not be exceeded for engines having plain slide valves. The device is simple,

DIMENSIONS OF FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE; PRUSSIAN STATE RAILWAYS.

Type of engine	Atlantic, or 4-4-2
Class of traffic	Fast passenger
Gage of track	4 ft. 8½ ins.
Fuel	Bituminous coal.
RUNNING GEAR:	
Driving wheels (4) steel center	6 ft. 5 15/16 ins.
Truck wheels (4) steel-tired	3 " 3⅛ "
Trailing wheels (2) "	3 " 5⅛ "
Tender wheels (8) "	3 " 3⅛ "
Driving wheel tires secured	By shrinkage.
Engine truck	Swing center
Journals, driving axles	7⅛ × 8 11/16 ins.
WHEELBASE:	
Driving	6 ft. 10 11/16 ins.
Truck	6 " 6 11/16 "
Total engine	29 " 6 5/16 "
Truck pin to first driving axle	9 " 8⅛ "
Tender truck	5 " 3 "
Total tender	14 " 9 9/16 "
Engine and tender	50 " 6⅛ "
WEIGHT IN WORKING ORDER:	
On driving wheels	67,000 lbs.
On truck wheels	29,020 "
On trailing wheels	26,630 "
Engine total	132,650 "
Water in boiler	1,600 gallons.
Tender, empty 41,845 lbs.; loaded,	95,600 lbs.
Tools on tender	840 lbs.
Piston, h. p. 78 lbs.; l. p.	156 lbs.
Piston rod, h. p. 67 " l. p.	108 "
Main rod, h. p. 244 " l. p.	182 "
Crosshead	152 "
Side rod	220 "
CYLINDERS:	Four.
High pressure (inside frames)	14 9/16 × 23¾ ins.
Low pressure (outside frames)	22 9/16 × 23¾ "
Ratio of area of h. p. to l. p. cylinder	1:2.44
Cubic contents of all cylinders	14.75 cu. ft.
Crosshead and guides	Sleeve, single bar.
Connecting rod; length, c. to c.	5 ft. 8¼ ins.
Side rod	Solid ends, slotted.
VALVE GEAR:	Heusinger von Waldegg.
Ports, steam, h. p., diam.	7 1/16 ins.; width, 1 5/16 ins.
Ports, exhaust, h. p "	7 1/16 " " 5½ "
Ports, steam, l. p, length	18½ " " 2 "
Ports, exhaust, l. p. "	18½ " " 2⅝ "
Bridges, width, h. p., "	1¾ " l. p. 1 9/16 "
Eccentrics, throw	8 11/16 "
Slide valves: h. p., piston	l. p. Allan-Trick.
Max. travel, h. p.,	5 1/16 ins. l. p. 6 1/16 ins.
Inside lap (neg.) h. p.,	5/16-in. l. p. 1/32 "
Outside lap, h. p.,	1⅝ ins. l. p. 1⅝ "
Lead, in full backward and forward gear	¼-in.
BOILER:	Straight top.
Barrel, diameter inside smallest ring,	4 ft. 8 11/16 ins.
Dome, diameter	2 " 17/16 "
Barrel plates	13/16 "
Smokebox tube plate	1 "
Horizontal seams; butt joints	Double riveted.
Circumferential seams	" "
Rivets, diameter	⅞ in.
Height, rail to cen. line	8 ft. 2½ ins.
Smokebox, length including extension,	7 " 2⅝ "
Spark arresting device	Inverted cone of netting.
Injectors, two	Schaeffer & Budenberg restarting.
Working steam pressure	200 lbs.
FIREBOX:	Copper.
Length, inside	4 ft. 8 9/16 ins.
Width, inside	6 " 39/16 "
Depth at front and back	5 " 4 9/16 "
Crown, back and side plates	11/16 "
Tube plate	1 1/16 "
Crown stays	Vertical.
Firebrick arch	Yes.
Stayboits	solid, copper; with tell-tale holes.
" diameter, three top rows	1 3/16 ins.
" " all others	1 "
" pitch	4 to 4¼ "
Water spaces, width at front, back and sides	5 "
TUBES:	Solid drawn iron.
Number	241
Thickness	0.1 in. (about 5/32-in.)
Pitch	2⅜ ins.
Diameter, outside	2 "
Length between tube plates	14 ft. 7 5/16 ins.
Total area of tube openings	4.13 sq. ft.
HEATING SURFACE AND GRATE AREA:	
Heating surface, tubes (interior area)	1,632 sq. ft.
" " firebox	108 " "
" " total	1,740 " "
" " superheater (inside the tubes)	279 " "
" " superheater (outside the tubes)	310 " "
Grate area	29 " "
Ratio of total heat. surf. to grate area	1 to 59.60
Ratio of interior tube area to firebox heat. surf.	1 to 26.37
Sq. ft. of total heat. surf. to 1 cu. ft. of cyl. vol.	1 to 118.00
Sq. ft. of firebox heat. surf. to 1 cu. ft. of cyl. vol	1 to 7.30
Sq. ft. of tube heat. surf. to 1 cu. ft. of cyl. vol.	1 to 118.00
Sq. ft. of grate area to 1 cu. ft. of cyl. vol.	1:2
MISCELLANEOUS:	
Exhaust nozzle, single, diameter	5 11/16 ins.
Exhaust nozzle, below cen. line of boiler	9 9/16 "
Smokestack, diameter at top	1 ft. 8⅝ ins.
" at base	1 " 4⅝ "
" height above smokebox	3 " 0 9/16 "
" height of top above rails	13 " 10 "
Brake fittings: Westinghouse on driving wheels and tender; hand-brake on tender.	
Total adhesive tractive power at ¼ of weight on driving wheels	16,750 lbs.
Ratio of tractive force to weight on driving wheels	1:4.15

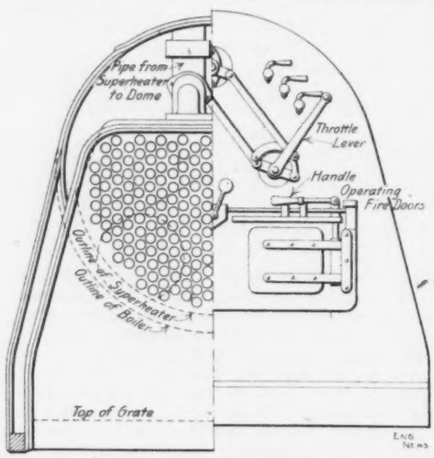

Fig. 2. Firebox of German Locomotive.

with no working parts, and is claimed to be more economical than superheaters placed in the smokebox, because (within certain limits) it can be put where the gases are at the highest temperature. A diagram of a run from Berlin to Halle with a locomotive of the type above described and equipped with a Pielock superheater is shown in Fig. 8. The following is from a statement by the builders of the engine above described, who are the owners of the patents on this system of superheating:

The accessibility of the boiler tubes is not worse after the superheater is put in position than before. Washing out of the boiler can be done just as well, because there is a space between the superheater and the boiler. The superheater does not necessitate any alteration to the locomotive to which it is applied, as it will be built to suit the boiler. The superheater is floating, and therefore does not cause any alteration in the distribution of the weight of the locomotive.

The superheater is safe in working, as the pressure inside and outside is the same. The strain on the boiler-tubes remains the same and overheating of the tubes is impossible if the superheater is so far from the firebox that the temperature of the heating gases does not exceed 700° to 800° C. The steam which passes rapidly through the tubes at high speed cools them as effectually as the water which surrounds the tubes and which has usually a slow motion.

When the locomotive is at rest, no steam is passing through the superheater and the temperature of the heating gases in the tubes is falling so quickly that it is impossible to overheat the tubes; the superheating steam however is still going on, and on starting the locomotive, there is always superheated steam. If a leakage should occur, it can be detected not only by the thermometer, but also by the draincock. A small leakage does not do any harm, because a small quantity of water will be evaporated. A large leakage will not affect the working of the locomotive, but only the working of the superheater.

The trials already made have been very satisfactory. The saving in coal was on an average 15 to 18% and in water about 20%. The superheaters are, therefore, of great importance for railways where the price of coal is very high and the water supply is bad. It may be mentioned that after opening the regulator the temperature of the superheated steam increases very quickly and can be kept very even with a good fire, and that after closing the regulator, the temperature decreases very slowly (per minute about 1½° C.) so that on starting again, there is always superheated steam.

This interesting locomotive (with its superheater) is exhibited by its builders, the Hanoversche Maschinenbau-Actien-Gesellschaft, of Linden (near Hanover), Germany, and we are indebted to the builders for plans and other information. It is one of 20 ordered this year, and after the exhibition it will be delivered to the Prussian State Railways. It may be of some interest to note that it is painted a dark green, with bright red wheels, and has a very high degree of finish.

The general dimensions of the engine are given in the accompanying table in our standard form.

MAINTENANCE OF MACHINERY IN MERCHANT SHIPS.*

By Robert Haig, M. Soc. N. A. & M. E.

The maintenance of machinery in merchant ships is a problem that is steadily becoming of higher importance by reason of the increase in size and power, the greater complexity and detail now found on board high-class vessels, and also because of the greater demands now made for a higher efficiency in the machinery.

ENGINE FOUNDATIONS.—The practice now usually followed where a vessel is fitted with a double bottom is to put the engines right down on the tank top, the scantlings of the inner bottom having been made heavier for that purpose. Very serious trouble is met with by holding-down bolts breaking and becoming loose, by engines working on the seatings, and this will always ensue unless the highest quality of workmanship is put into the double bottom in the machinery space. The intercostals should be well fitted; the rivet holes should be absolutely fair; the countersinking of the holes in the tank-top plating should be almost, if not the whole, depth of the plating, and the rivets laid up with good full points, so as to ensure a thoroughly strong connection. When we con-

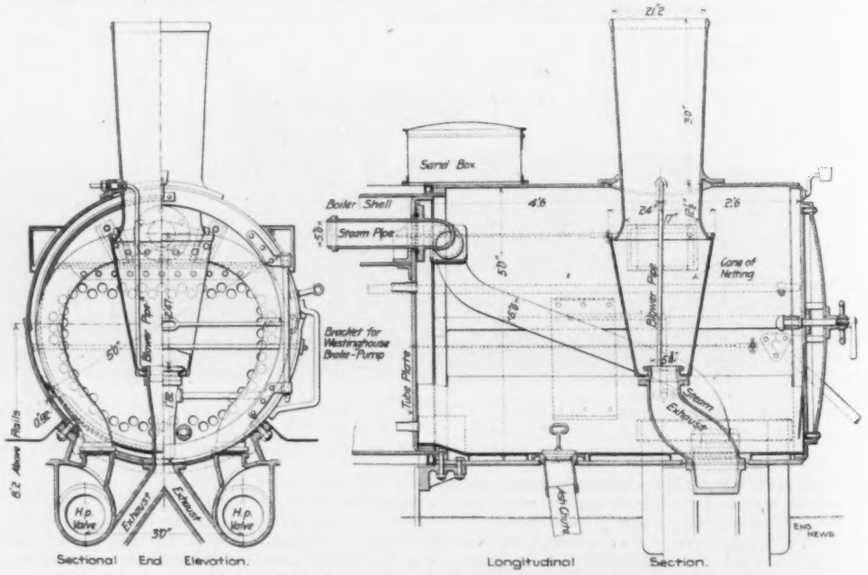

FIG. 3. SMOKEBOX AND FRONT END ARRANGEMENT.

*From a paper read before the Society of Naval Architects and Marine Engineers, New York, Nov. 17.

sider that a pull must come on this work when the engines are swinging about, it will be seen how very necessary it is that the holding-down bolts should take hold of a good foundation.

SHAFTING.—Although last winter was one of the most severe of recent years, the number of broken crank shafts was comparatively few when compared with the failures of past years. This can readily be explained by the higher quality of material of which shafts are now made, by the increased attention given to the bearings and keeping the shafts in alinement, and also no doubt to the improved design and construction of the engine bedplate foundations.

Although for very sufficient reasons solid-crank shafts are still used in warships, they are in merchant ships a thing of the past, and we have instead built-up crank shafts of nickel and carbon steels of the highest quality, with the result that broken crank shafts are exceedingly rare.

In the early days of built-up shafts no doubt there were many failures, and loose crank pins and unfair shafts were common, but higher quality of material, greater experience and accuracy in machining, improved methods and knowledge of shrinking the various members together, have resulted in producing shafts as nearly mechanically perfect as could be desired.

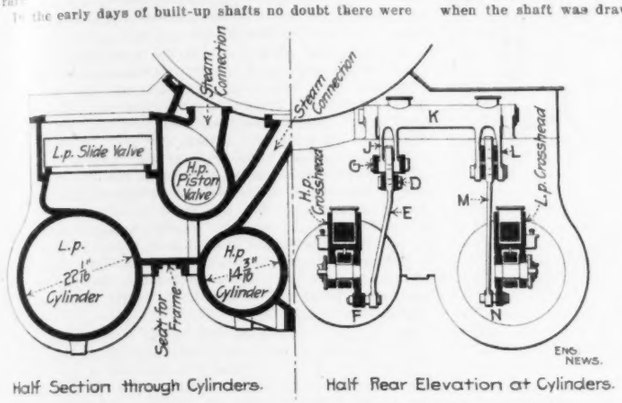

FIG. 4. SECTIONS AT CYLINDER AND VALVE GEAR.

Propeller shaft troubles have been numerous. If we had only the torsional stresses set up by the power transmitted from the engines to deal with, this could be readily met by increasing the size of the shaft until the weakness was overcome; but a brief analysis will show that the stresses borne by the propeller shafts are of a widely varying nature. We have the stresses set up by the overhung weight of the propeller which in some cases reaches 25 tons, also the bending stresses due to the change of the center of effort brought about by the continuous variation in the immersion of the propeller, and which reaches its maximum when a vessel is pitching heavily or in a more or less light condition, and, further, the abnormal stresses developed by the rapid acceleration and as sudden retardation of the momentum of the propeller when the engines are racing. These all combine to produce conditions that demand a very high grade of material and workmanship in the propeller shaft and stern bearings.

There is a further troublesome factor to be considered, namely, the wastage on the propeller shaft at the ends of the brass sleeves due to the so-called galvanic action or fatigue. Happily this latter feature of the trouble has been to a large extent eliminated of late by protecting the shaft with brass sleeves for its entire length, thus doing away with what has hitherto been a serious menace to the life of propeller shafts. In some cases the brass sleeves are put on in one length, which course is much to be desired, but where the shafts are long and the sleeves require to be built up of several lengths the greatest care should be observed to have the joints of the sleeves perfectly water-tight, as leakage at these parts causes scoring, and the shaft may rapidly become unsound without giving any outward evidence of the fact.

Considerable success has been attained by running propeller-shafts without any brass sleeves whatever, the stern-tube being sealed at the outer end by a patented arrangement, which allows for the stern-tube being filled with oil. White metal is fitted into the stern bush instead of the ordinary lignumvitæ and the stern-tube being filled with oil, this makes an oil bath for the shaft and bearing and reduces wear and tear to a minimum.

Under these conditions the S. S. "Clematis" was in commission for five years and nine months, in which time the vessel steamed a distance of 156,000 miles, and when the shaft was drawn for examination the wear on the stern bearing was found not to exceed 1-16-in., and on the shaft it was practically nil, with the surface of the shaft preserved clean and bright and free from any wastage.

In some long ships of high power flexible couplings have been fitted in the line shafting, generally one at either end, to relieve the stresses due to bending or other movement of the ship's structure. These couplings have not been very widely adopted, as many engineers fail to see the utility of them, and unless of the very best make their bearing surfaces wear rapidly and by their looseness cause considerable noise and jar when the engines are running at unequal speeds.

CONDENSER. — The condenser seems to be the part of the machine that has changed least with the evolution of the present-day marine engine. The principal change has been that the condenser has been detached from the main structure of the engines and is now in many cases being carried higher up on a built-up seating, which arrangement allows for better drainage to the air-pumps, easier leads for inlet and discharge piping, and also gives greater access for overhauling the main engines.

Surface condensers, which are really now the only condensers we may consider in marine work, have serious troubles from leaking and faulty tubes. Steamship owners and other authorities have spent considerable time and money in experimenting with the various kinds of tubes, but so far the results have neither been very encouraging nor satisfactory.

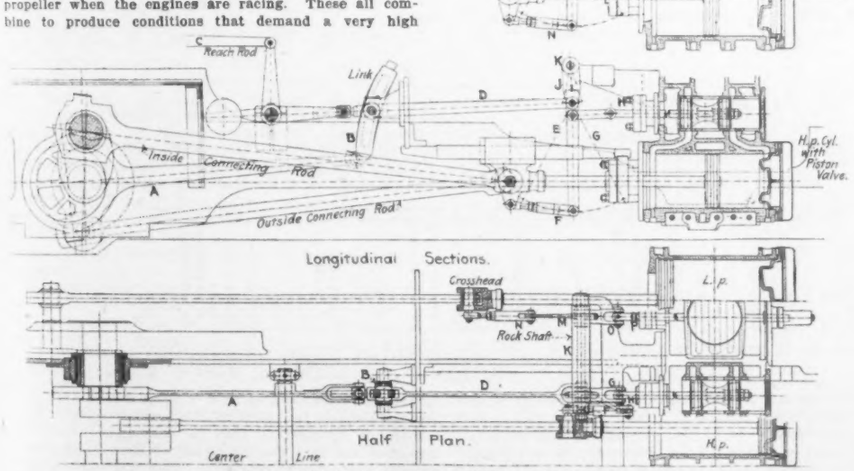

FIG. 5. VALVE GEAR OF GERMAN LOCOMOTIVE.

The trouble usually found is that after a short time in use, the insides of the tubes are found to be eaten away in spots, and pin-holed, as if some active erosive action had been taking place and had attacked certain parts of the material, which is evidence enough to some minds that the tubes are not altogether homogeneous.

The various methods of packing condenser tubes have undergone little change, the screwed-in gland being what is now most commonly used, but the materials used in packing the tube ends have changed frequently and have given considerable trouble. Rubber rings, fiber rings, waxed cotton lacing, and lacing soaked in linseed oil have all been tried in turn, but experience has shown that lacing soaked in oil and properly packed in place makes the most satisfactory job and lasts well under the various changes of temperature. Wooden ferrules soaked in oil and driven into the tube plate makes a much cheaper method of packing a condenser, but has this disadvantage, that if the vessel should be laid up and the condenser remain dry for a length of time the ferrules shrink and split, and before the condenser can be made tight the ferrules require to be renewed. The packing of condensers is generally supposed to be a simple operation, not requiring any great skill or experience, but the results of hurriedly and imperfectly packed condensers are frequent sources of delay and trouble with feed water when at sea, and I am strongly of opinion that the greatest care and attention should be given to the operation of packing, and when the condenser is filled for testing, it should be with warm water of a temperature not less than 200° F.

Fig. 6. Pielock Superheater for Locomotive. Hanoversche Maschinenbau-Actien-Gesellschaft, Makers.

Various reasons have been advanced to account for the leaking of condenser tubes; the most prominent theory being the leakage of electric current from the electric generating plant on board, or the galvanic action set up by other conditions existing on board the vessel.

A further reason given is the bad quality of the stream of water sent through the tubes when the vessel is docking, or proceeding up or down a river. If the water in which a vessel is lying is contaminated with sewage and other foul matter usually found in river water near large cities, this water in its passage to and through the condenser is bound to produce conditions inimical to the life of the tubes, the worst feature being that when the circulating pump is brought to rest, this foul and active matter remains in the tubes until the vessel leaves port, during which time I am firmly convinced most of the mischief occurs. If some simple means were adopted for washing out and draining the condensers as soon as practicable after the vessel is docked, it would amply repay for the trouble taken.

The claim that electric leakage is a cause of the deterioration in condenser-tubes is one that has given rise to widely different opinions for the reason that the trouble has been quite as acute in ships without any electric generating plant, nor does it seem to make any appreciable difference whether the vessel is wired on the single or double-wire system. While able reasons have been advanced in support of the theory that the return currents in the single-wired system, or stray currents from defective insulation and connections in the double-wire systems, should be accepted as the cause of deterioration in condenser-tubes, it is at present difficult to take this as being the only cause; there does not seem any reason why the electric current should single out the tubes for attack when there are other metals of almost the same

composition, exposed to the same conditions, which do not suffer to anything like the same extent.

Numerous devices have been adopted to counteract the deterioration in the tubes, and the most successful has been to line the water ends of the condensers with rolled zinc plates on studs fitted in the tube plates. This has been found to improve conditions quite considerably, but is not by any means a panacea for the ills that condensers are heirs to; such a cure will only be arrived at by continued and persistent effort.

BOILERS.—In dealing with the present high pressure Scotch boiler, it will be generally agreed that it has now reached its limit in size, thickness of plating and pressure, and although a few boilers of reduced diameter

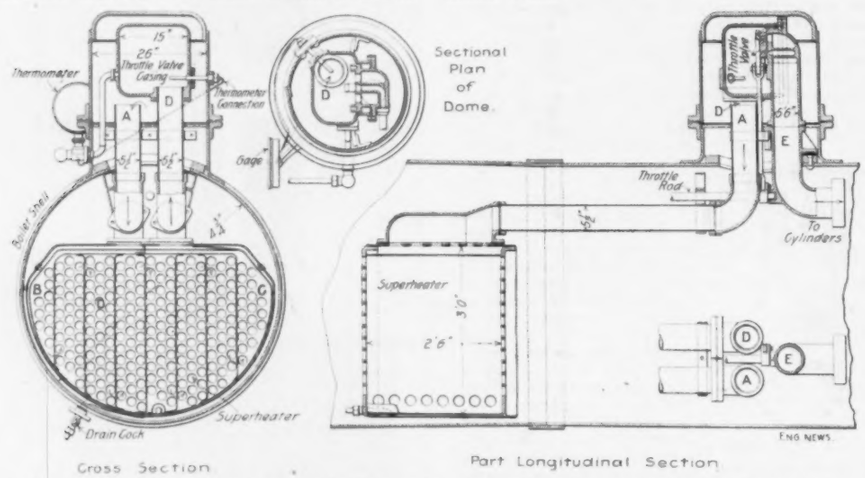

FIG. 7. DETAILS OF PIELOCK SUPERHEATER ON COMPOUND LOCOMOTIVE; PRUSSIAN STATE RAILWAYS.

have been built for pressures up to 267 lbs. per sq. in., the pressure that is found in most general use in our latest boats ranges from 200 to 215 lbs. per sq. in. The maintenance of boilers with the higher pressures now in use has not materially altered from the conditions existing when lower pressures were dealt with, so long as the conditions of combustion are the same, or, in other words, with natural draft; but as a large proportion of ships are now fitted with assisted draft of one type or another, it is considered desirable to discuss the maintenance of boilers under forced draft conditions. Experience has undoubtedly shown that the working conditions of boilers under forced draft, can be made radically different from the conditions which exist under natural draft. The question of forced draft will be dealt with later on; at present it is proposed to discuss the effects on the boilers only. In natural draft we have the temperatures in the combustion chambers due to energetic working of the fires and the draft produced by the funnel, which at no time becomes so excessive as to cause damage to the chamber plates, unless the boilers are allowed to become very dirty from scale on the water side.

With forced draft we have temperatures in the furnaces and chambers of much greater intensity, and which are only limited by the amount of coal capable of being burned on the fire-grate and the air pressure obtained in the ash pits, with the result that the combustion chamber plating becomes locally overheated and buckling takes place, stay-nuts are burned off, tube ends leak, and the plating cracks through the landing edges of the rivet holes, and this is especially severe in places where any broad landings or doublings are exposed to the flames. Various means have been adopted to protect the surfaces at the back ends, most affected by the flame, by fitting tiles made of fire clay or other refractory material and molded to the shape required, but their usefulness is sometimes of short duration, owing to the difficulty of keeping them in place, as the means taken to secure them are rapidly burned off. The most serious trouble met with is in the corners of the furnace plating where it is flanged up to take the back tube plate, and here, unless the radius of the flanging of the tube plate has been of an easy nature, cracking very soon develops, and as this takes place through a riveted connection, to repair which a three-ply thickness of material will be necessary in places, it is found almost an impossibility to keep this place tight in boilers under forced draft conditions. It is true this weakness has been somewhat modified by the adoption of the furnace with the "Gourlay" neck but even with this improvement the difficulty experienced in keeping this joint tight is quite acute, as the riveting and calking requires frequent renewal, and each time it becomes more serious than before by reason of the deterioration of the material causing cracking through the rivet holes and landings.

The other most frequent weakness is shown in the riveting of the furnace to the back tube plate, right over the furnace crown. This joint is in many cases double riveted, and with two thicknesses of material of a breadth sufficient for a double-riveted joint exposed to the hottest part of the flame, it is found extremely difficult to keep it tight, as the part of the plating exposed becomes overheated and weakened and the movement resulting from this overheating gives rise to extensive leakage. A single-riveted joint has been found to stand perfectly well at this part, and there is no good reason why it should not do so if the spacing of the riveting is properly designed and the work is of the best. It is at this part that protection as previously referred to by fire-brick blocks is urgently required, and when the voyage is short and the blocks can be frequently renewed, they are an undoubted benefit.

In the S. S. "Finland" the builders had the whole of the combustion chambers of one boiler welded throughout, the only riveting being the attachment of the furnace to the back-tube plates. This was found to be a highly satisfactory job and has not, I understand, given any trouble whatever, the increased cost, I think, being the only objectionable feature.

In the case of the nuts of stay-bolts being burned off, this has been met by doing away with the nuts on the stay ends that come in a direct line with the furnace, and reverting back to the old practice of riveting the stay ends over which has been found to answer very well.

The chief engineer of one of the large mail boats sailing out of this port furnished me with data showing that if the cleaning of a fire could be kept within a certain number of minutes no bad effects to the tube plate and furnace joints were observable; but when from dirty fires or other reasons the operation was protracted beyond the stated time, leakage would commence and continue until the fire was well under way again. He also informed me, and this I personally observed, that where this leakage had taken place, careful inspection showed that the calking had been sprung by the lowered temperature, causing local contraction in the furnace and combustion chamber connections.

The experiment was tried of putting two men to clean a fire so as to reduce the time required, and the results showed beyond a shadow of doubt that the leakage was directly due and proportional to the length of time the furnace door was open.

Longitudinal cracks in furnaces are usually observed after the furnaces have been in use for some time, and are generally found to develop about the middle of the length of the furnace in small hair-like cracks showing up on the points of the corrugations nearest to the fire. These faint cracks steadily increase in length and extend into one another until they become so bad that they require to be pinned or the furnace removed altogether.

The cracks in the furnaces are undoubted evidences of fatigue, produced from the stresses set up in a vertical direction by the unequal expansion and continuous movement due to the change of temperature, between the upper and lower halves of the furnace, and localized along th line of fire bars where the furnace is weakened owing to the intense heat and excessive wear at this part. Cracks of a more serious nature sometimes develop in a circumferential direction in furnaces; this is due to fatigue, but rather to carelessness in manipulation of the boilers.

A case came under the writer's notice some time ago where in a vessel the morning after arrival in port, upon the engineer's proceeding to examine one of the donkey boilers, that had been blown down 24 hours previously, they discovered a crack 20" long in a circumferential direction in one of the lower furnaces. The crack in the furnace was temporarily repaired, and upon the vessel's return to this country two months afterwards a crack of similar size was found under precisely the same conditions in one of the other boilers.

Inquiry elicited the fact that it was the practice to lay off for cleaning purposes one of the boilers in rotation, while the vessel was in port on this side, the "modus operandi" being to draw fires, blow down the boiler and drop in the manhole doors as soon as practicable after the vessel was made fast in dock.

It was pointed out to the engineer that this mishap was altogether preventable and was due to a lack of appreciation of the care necessary in handling boilers. The conditions were simply that the boiler in a limited space of time had all the heat and internal pressure removed and the empty boiler was then exposed to the chilling effect of a 36-in. down-take ventilator discharging in front of the boiler air of a temperature near to freezing point as it so happened that it was in the winter months that the damage occurred.

Arrangements were made that in the future, upon the fires being drawn, the furnace door and ash-pit dampers should be closed, the ventilators turned back to wind and the water left in the boilers to be pumped out next day, and since this has been done no further trouble with the furnaces has been experienced, clearly demonstrating how urgent the necessity is for a better appreciation of the care requisite in dealing with boilers.

Cracking in the knuckle of the flanging of the lower front heads and distortion of the boiler bottoms is in some cases a serious trouble from the very start, due in a great measure to design. These stresses at these parts are very severe indeed, in some cases causing rupture of the shell plating through the line of circumferential riveting in the bottom of the shell, and cracking along the knuckle of the flanged part in the lower head. Investigation has demonstrated that to the differences of temperature between the top and the bottom of the boiler, causing unequal expansion of the shell-plating and boiler ends, is due the distortion previously mentioned. Leakage at the boiler bottoms is difficult to cure, as heavy plating and rivets cannot be efficiently laid up by hand, and least of all in a confined space under a boiler bottom.

The flanging of the lower heads when examined inside show fatigue markings similar to the fine cracks shown on the fire side of the furnaces, and these in time develop upon the outside of the flanging also, and become so serious as to require the lower head to be repaired or renewed.

This cracking is found to develop at an early date in

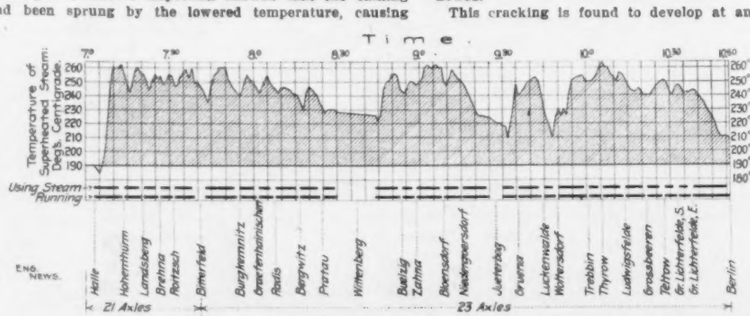

FIG. 8. DIAGRAM OF TEMPERATURE OF SUPERHEATED STEAM ON LOCOMOTIVE DURING RUN FROM HALLE TO BERLIN, PRUSSIAN STATE RAILWAYS; MARCH 16, 1904.

boilers where the flanging is of a small radius, showing that the plate in its efforts to accommodate itself to the changes of temperature and the movement resulting thereupon had been distressed, and of course where the material is fatigued to this extent there is a known limit to its endurance.

The lower heads also suffer from wasting caused by the water draining from the hot ashes corroding the fronts of the boilers. This, however, is to a great degree preventable and can be taken care of.

The lower heads as a result of the excessive flanging done upon them are peculiarly susceptible to corrosion on the knuckle of the flanging, and where this wasting is allowed to go on fatigue of the material follows very rapidly, and where rupture takes place at this part it is a

difficult and costly business to repair, coupled with the fact that it can never be kept tight.

FORCED DRAFT.—Forced draft has certainly been a most valuable development in engineering, the proof of which need not be presented here; the main question arising in this paper being the effect that forced or accelerated draft has had upon the life and maintenance of boilers.

The two systems to be found in merchant ships are "Howden's Forced Draft" and "Ellis and Eaves' Induced Draft," each of which in competent hands is capable of working the boilers at a very high efficiency. The closed stokehold system has confined itself largely to warships and will not be considered here.

The effect of forced draft upon some boilers has been very marked indeed, and the question is of far-reaching importance as to what is the best air pressure to be carried in the ash-pits. In some vessels one-half inch is considered sufficient, and is then really an assisted draft, while in others pressures up to about three inches are carried in the ash-pits. It would almost seem as if somewhere between those two extremes would be found the desirable mean, but after close observation I am firmly of opinion that in shell boilers at all events the pressure in the ash-pits should not exceed one inch of water at any time. I have examined many boilers where high air pressures have been in use, and the results have been always the same—buckled and cracked plating, stay nuts burned off, caulking started, and leaky tubes, whereas, when the air pressure was not allowed to exceed one inch the condition of the boilers was as good as of those working under natural draft.

The maintenance of boilers under the higher air pressures is altogether out of proportion to the extra work got out of them, with the further result that a continuance of these higher pressures will cut out not less than 30% of the useful life of the boiler. The further objection to high air pressures, and it is a potent one, is that there can be no attempt at coal economy with excessive pressures, as experiments and trials without number have fully demonstrated. The temptation is keen to use higher air pressure when making up time, when coal is bad, or in the endeavor to get a power out of the boilers that their size does not warrant.

These remarks can be applied to water-tube boilers also, although their physical condition is not so seriously affected as the shell boiler; but experience will show that even there a moderate air pressure in point of maintenance and coal consumption will be found more than desirable.

OIL FUEL.—The maintenance of boilers working with oil fuel is, at the present time, of decided interest in view of the possible development in this direction. It is not proposed to deal with the question of oil as a fuel, but rather to consider its adaptability and its effect upon boilers. The use of oil fuel has been with few exceptions confined to oil-carrying steamers, but there is not any structural reason to debar its use in ordinary cargo or passenger ships as the fuel can be carried in the double bottom and in tanks fitted in the usual coal bunker spaces. With proper precautions taken the risk of explosion is very remote, as the flash point of the fuel is usually not less than 150° F. When the fuel is carried in the double bottom a heavy layer of cement 3 ins. thick, properly sectioned off to keep it in place, has proved to be a good insulator for the tank.

The two systems most widely applied to burning oil fuel are compressed air or spraying by steam. The former requires a small air compressor, or other suitable means for obtaining the required pressure which is usually about 1-in.; the other method, spraying by steam, requires the installation of extra evaporators to make up the loss of water used in spraying the oil, which is found to be about 3% of the total steam evaporated. With the compressed air a certain amount of steam is, of course, required to drive the air compressor, but there is no doubt that with the air heated to a high temperature this process will be found to show a high efficiency, especially in long voyages, as under oil fuel conditions the combustion and the steam are steady, which always means economy.

The condition of the boilers after using oil fuel is found, when the necessary safeguards have been taken to protect the surfaces of the combustion chamber from direct impact with the flame, not to differ to any material extent from that of boilers burning coal.

The combustion chamber backs and sides require to be protected with brickwork carried up above the level of the furnace crown, and in most cases the furnaces are bricked over also, and arrangements of brick arches erected in the furnace to baffle or break up the torch-shaped flame within the length of the furnace. When these conditions are properly carried out, the boilers show not the slightest sign of distress, but if the brickwork is allowed to come down it means that the flame strikes straight through into the chamber; the furnace does comparatively little work, intense heat is localized in the combustion chamber back and tube plates, causing serious distortion and leakage.

I have examined boilers that were less than twelve months in use, where the combustion chambers were seriously damaged from neglect to keep the brickwork in good condition.

MAIN AND AUXILIARY STEAM PIPES.—The necessity for a good pipe arrangement was never greater than at the present time. As stokeholds extend in length the demand for well designed main steam pipe lines is very urgent, so that the losses from drop in pressure between the boilers and engines should be kept as low as possible. As long lines of steam pipes have considerable movement when under steam, the greatest care should be taken to avoid any abrupt changes in the direction of the line of piping, and where it is found necessary to make changes, expansion joints should be fitted and so arranged that it will not be possible to subject the bends and other connections to any stress beyond that due to the boiler pressure. Main steam-pipe flanges should not be bolted to bulkheads unless expansion joints are in the immediate vicinity, and so arranged to take up any movement in the bulkhead that may take place; and never under any considerations when struts carried from any other part of the machinery are attached to the bulkhead in proximity to the steam pipes, as grave danger is to be apprehended in this arrangement in the event of the vessel grounding or meeting with other serious damage. Long lines of steam piping mean considerable condensation, and ample means should be taken to ensure this water being trapped, and where this is done automatically hand drains should also be fitted, so that in the event of any of the lines being laid off temporarily, the engineer will always be able to inform himself as to whether the pipes are clear of water before turning steam on.

The arrangement of auxiliary steam lines in many cases leaves much to be desired; pipes are dropped down to low levels to get round some obstructions, then raised abruptly to higher levels, thus forming a pocket which is a lodgment for water, and besides being a positive danger, it lowers very materially the efficiency of the whole auxiliary outfit.

PUMPS.—One of the greatest advances made in the development of the present triple or quadruple engine has been in relieving the main engine of the duty of driving the pumps and using the power for propelling the ship only.

The long stroke slow working simplex feed pumps now in use, when fitted with automatic speed regulators, give good results; the feed line is not subjected to shocks and as the pump only works when there is water to pump, it means that less air is forced into the boiler along with the water. As the water ends of high-class feed pumps are of brass, the valve seats should be cast solid with the chamber; removable seatings that are only "driven in" should not be accepted, as they are sure to become loose unless they are well secured in place by screwed pins through the flanges into the chamber, and as these pumps require to pump water that is well over 200° F. against a high pressure, this class of pump requires to be of substantial make and the best workmanship; otherwise, they are a continual source of trouble.

One other good feature of the independent feed pump, especially in large installations, is that they are usually fitted in pairs and interchangeable, which means that the breakdown of a feed pump is not so serious as formerly, and as most pumps of this class have considerable reserve capacity any mishap occurring to put a pump out of action does not affect the speed of the vessel.

The whole array of auxiliary or independent machines, such as feed, bilge, ballast, air, circulating and sanitary pumps, electric light, blower and ventilating fan engines, etc., now usually fitted, are an elaboration of the idea of separate units for each particular service, and have in most cases been found to do their work remarkably well; but it has to be remembered that the maintenance of such large number of steam users in even a moderate degree of efficiency, entails a large amount of work and expense, and as many of these auxiliaries are so placed that examination and repair are difficult to accomplish, it can be easily understood that they are neglected and become most uneconomical steam users. This feature of auxiliaries is perhaps not much considered, but investigation will disclose what a surprisingly large proportion of the boiler power is absorbed in driving the auxiliary machinery.

Electric power in some cases has been made use of for driving quick moving auxiliary machinery, such as blower and ventilating fans, centrifugal pumps, etc., and that there is a wide field for electric power in this direction is undoubted, for although the first cost of the electric installation is greater, the up-keep and losses are much less. There is at present a certain amount of distrust in the minds of many engineers against electric motors taking the place of the steam engine when a positive action is demanded. That there is considerable force in this objection will be realized in the event of the motor attached to the circulating pump breaking down when leaving the dock, and bringing the engines up from lack of vacuum, and there is this further danger, that, as circulators are carried low down, an excess of water in the engine room might very easily put the motor out of action altogether. Notwithstanding the objections against the use of the motor, I firmly believe that their use will become general where continuous running is required, and if the motors are properly cared for and not overloaded, satisfactory results will be obtained. Cross-connections are always arranged for to provide against such contingencies as the breakdown of the circulator, but unless electricians can produce a motor proof against the effects of oil and salt water circulators should not be electrically equipped.

The question as to the best steam pressure, in point of economy and efficiency for operating auxiliaries, is of decided interest. It does seem an anomaly to raise steam up to the high pressures in use at present, about 210 lbs., and then wire-draw it through a reducing valve down to 100 lbs. to make use of it.

Few auxiliaries are well adapted or kept in such mechanical efficiency to profitably use steam of the higher pressures, as the losses from radiation and condensation and other leakages are considerable, and as auxiliaries are not an afterthought, it would undoubtedly seem to be a better arrangement for a certain proportion of the boiler power to be designed for the lower pressure. The first cost would be decidedly less, as the price of boiler power and all the necessary fittings for 100 lbs. steam pressure is very much lower than it would be for 210 lbs. Some vessels have been arranged along these lines and the results have been very satisfactory indeed.

THE POWELL PROCESS OF PRESERVING TIMBER.

In most processes for the preservation of timber a preliminary seasoning is essential for the best results, and the neglect or omission of this is responsible for many cases of apparent failure of the treatment. In the Powell process, however, the freshly-cut timber is treated, and although the ordinary closed cylinder or retort is now used for the process, it is claimed that open tanks can be used for the purpose. After the treatment with the preservative solution the timber is dried in drying kilns. The process is the invention of Mr. William Powell, of the Powell Wood Process Co., which has established a plant at Stratford, near London, England. The following particulars are taken from the "Contract Journal," of London, but the actual composition of the preservative is not given:

The timber is first laid upon trucks, and so packed that the saccharine solution may have free access to each piece. The trucks are then run to the process cylinder, and from there to the drying rooms. The cylinder is 30 ft. long and 6 ft. 6 ins. diameter. The loaded trucks are run into the cylinder on rails, and are fastened down in order to prevent the timber from floating in the solution. When the cylinder is charged the door is hermetically sealed by strong clamps. The interior of the cylinder is surrounded with closed pipes, answering the double purpose of heating the solution by steam and afterwards cooling it by water. Although the present cylinder is sufficient for its purpose, experience already shows that an open tank may be substituted with advantage as regards economy in working and the first cost of the plant.

Suitable storage tanks are provided for holding various qualities of liquor, corresponding with the class of timber to be processed. Connecting these tanks with the cylinder is a series of pipes with valves, and two centrifugal pumps are employed for dealing with the syrup and circulating cold water. On a line with the front of the cylinder are the drying chambers, heated by a Blackman stove from which the air is forced by a 48-in. fan through the ducts leading into the chambers. Each chamber has a 36-in. circulating fan and can be heated or cooled independently. A 35-HP. horizontal engine supplies the necessary power to drive the pumps, fans, etc., and a Lancashire boiler supplies the required steam for both engine and process cylinder.

The timber is first boiled in a compound saccharine solution, whereby the latent air is driven out and the albumen of the sap coagulated. The timber is then allowed to cool in the solution until it is sufficiently impregnated, and finally it is dried at a high temperature. As the plant is simple and inexpensive and the cost of the saccharine solution low, while the labor required for the manipulation is small, the cost of the whole process compares most favorably with that of other methods of preserving and seasoning timber. We are informed that the process is applicable to every kind of timber, whether used for railway ties and paving blocks or for the finest cabinet work, while absolutely green, newly felled timber can be prepared ready for use immediately it is cut down.

THE MOST NOTABLE CHANGE FROM PRIVATE to public ownership ever made was the recent transfer to the Metropolitan Water Board of the property of the eight companies supplying what is known as "Water London." The actual transfer was made about July 1 and on Sept. 30 the board authorized the Bank of England to issue stock to the several companies, in payment for the respective purchases. The grand total involved was £26,284,609 or nearly $138,000,000. This stock, according to the parliamentary act providing for the purchase of the works, bears 3% interest, thus making an annual charge of $4,140,000.

THE PROGRESSIVE SINKING OF THE GROUND WATER LEVEL AND ARTIFICIAL GROUND WATER SUPPLIES.

By Prof. J. Gustav Richert.*

Many a bitter complaint has been made that the greedy water-works have dried out the ground, causing failure of crops and other calamities. In Germany the cause and consequences of the ground water scarcity of the Ruhr valley are generally commented upon, and in Holland the dissatisfaction of the population has resulted in petitions to the government to enact a law preventing, or at least limiting the draft of ground water, where such is proved to do damage to the surrounding districts.

Frequently the opinion is heard that when a certain quantity of water is drawn from a well the ground water level is caused to sink only within a district of certain limited size and that consequently this depression, largest in the well, and gradually decreasing, finally disappears. This granted, there would be no reason why outside of the "cone of depression" the ground water level should not remain unchanged. If a new well were sunk so far from the former one that their cones of depression would not intersect one another, then the new well would have no injurious effect on the old one, the capacity of which ought to remain the same as before. Thus damage to the old well is assumed to take place only in case of an obvious intersection between the two cones.

These calculations have too often been brought to shame, as, contrary to all precautions, the supply of water gradually decreases in proportion to the number of wells sunk outside of the sheltered district. This fact is proved by the many attempts made to prohibit the establishment of new wells within certain distances from ground water-works.

Let us examine the effect of a well on the level of the surrounding ground water. Fig. 1 shows a longitudinal section through a ground water stream with outlet into a river or other free water course.

Above A the ground water level is partly determined by the underlying impervious layer of earth or rock. To the quantity of water, K, correspond certain values of cross section, velocity and inclination. Between A and B the river has a retaining effect on the ground water stream, causing a rise of its level. The depth of the stream gradually increases, the velocity, resistance and inclination decrease in the same proportion. From A to B the water level forms a curve touching the upper rectilinear water level at A. Let us, to obtain simplicity, substitute A-B by a straight line.

If a certain quantity of water, k, is drawn from a well, C, situated above point A, there will appear round the well a depression cone D C E. Above this cone the quantity of water is still K, consequently the water level will remain unchanged above point D, where the cone touches the original level. Below the cone, where the quantity is reduced to K-k, the cross section correspondingly decreases, resulting in a sinking of the water level, which touches the cone at E. At F the retaining effect of the river begins to show its influence. Between F and B passes less water than before, consequently the line F-B is less inclined than A-B, and lies for its whole length below the same.

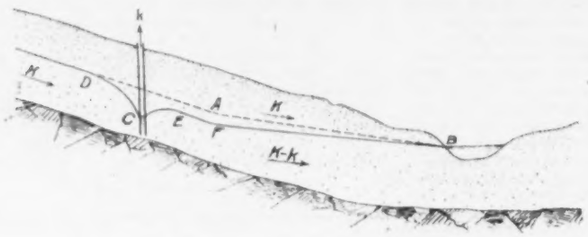

Fig. 1. Longitudinal Section.

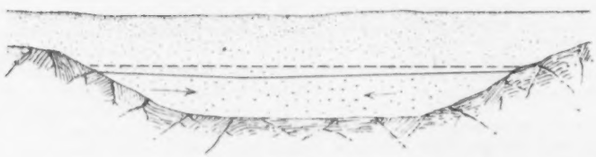

Fig. 3. Cross-Section at D (Fig. 1).

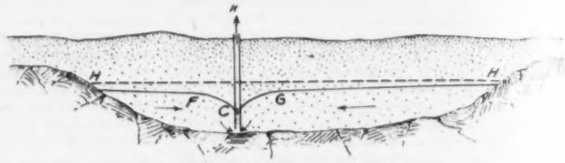

Fig. 2. Cross-Section at C (Fig. 1).

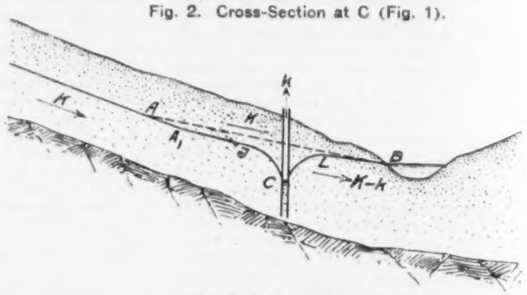

Fig. 4. Well at Lower Level.

FIGS. 1 TO 4. ILLUSTRATING EFFECT OF WELLS UPON GROUND WATER STREAM HAVING AN OUTLET INTO A FREE WATER COURSE.

A cross section through the stream at C is shown in Fig. 2. The depressing cone seemingly extends only to F and G. From these points the water level rises with a slight inclination to both sides, but it never reaches the former horizontal, H-H.

A cross section at D shows the same water level as before the pumping, and a cross section at E a slightly concave water surface (Fig. 3). Farther down the irregularities gradually disappear, although the inclination from both sides towards the level immediately below the well seems to indicate a deviation of the different particles within the stream.

If the well is sunk at some distance below the intersecting point A (Fig. 4) there is also formed a depression cone terminating up-stream at J, down-stream at L. Below the latter point the water level, raised by the retaining river, is naturally caused to sink, because the quantity K-k corresponds to smaller values of cross-section and inclination than K.

From A to J there still passes the quantity K, but the retaining effect of the river is lessened on account of the local lowering at C, and the point A will therefore be changed to A_1. Whether between A_1 and J the water level will be more or less inclined than above A_1 depends partly on the composition of the ground. In a homogeneous gravel bed, however, this inclination is smaller than above A, because the retaining influence of the river is to a certain degree maintained by the well. A cross-section at C will appear, according to Fig. 2, at J, or, according to Fig. 3, at L. Below A, that is, within the district influenced by the river, the water level will be lowered everywhere; above A it remains unchanged.

From this the following general conclusions are obvious:

The well effects on the ground water stream not only a local lowering (cone of depression), but also a general lowering caused by the abstraction of the ground water.

If the level of the ground water stream is independent of any river or receiving basin the general lowering will cease at a certain distance above the well.

If, on the contrary, the stream is retained (and this is most generally the case), the lowering extends over the whole district influenced by the river.

The nearer the well is placed to the river, the less will be the general lowering of the ground water level.

Piefke has proved in an interesting pamphlet on the ground water question in Berlin that the Spree is receiving a ground water stream of an immense capacity, which might be efficiently utilized by means of wells along the river banks. If the ground water level is sunk only 1 in. below the free surface of the Spree, then every drop of the ground water stream will be drawn through the wells. If the wells are arranged in immediate proximity of the banks, where the ground water stream has nearly the same level as the river, then the ground water level needs to be lowered less than 1 ft.; if, on the contrary, the stream is cut off further up, where its surface is higher, then the lowering required will be considerably larger. In view of all the important interests depending on the ground water level every engineer ought to follow as closely as possible the general rule laid down by Piefke for the new ground water supply of Berlin. The natural variations, to which is submitted the ground water level during different seasons of the year, should never be augmented.

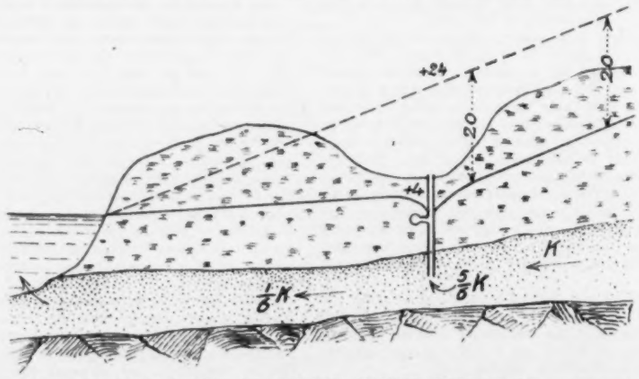

FIG. 5. SECTION THROUGH WELL IN GROUND WATER STREAM AT MALMOE, SWEDEN.

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Piefke's principle, perfectly corresponding to the state of matters in Berlin, has by some engineers been taken, as a rule, appliable to all ground water-works. It is not practicable, however, in cases where a ground water stream must be cut off considerably above its outlet.

As an example, may be mentioned the ground water plant of Malmoe, in Sweden, where an artesian stream running into the sea must be utilized so high up in the country that the water in the collecting wells arose to 79 ft. (24 meters) above the sea (Fig. 5). Below the wells the ground water level is lowered to 13 ft. (4 m.); the inclination is consequently reduced to 1-6, and by the same fraction is represented the rest of the stream emptying into the sea, 5-6 being drawn through the wells. Above these, or above their cones of depression, the capacity of the stream and the inclination of the pressure line remain unchanged. Here the ground water level sinks 66 ft. (20 m.) below the wells, or as an average 33 ft. (10 m.) on both sides, causing great damage to several communities and private properties.

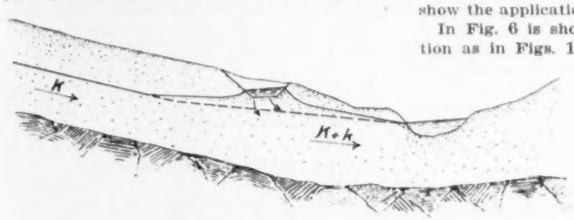


Fig. 6. Longitudinal Section Under Conditions Similar to those Shown in Figs. 1 and 4.

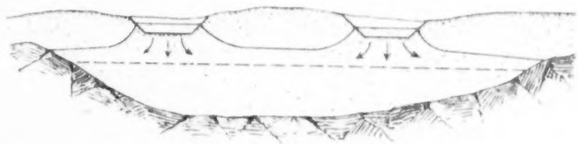


Fig. 7. Cross-Section, Showing Two Basins, for Alternate Emptying and Cleaning.

FIGS. 6 AND 7. SHOWING EFFECT OF INFILTRATION RESERVOIRS ON GROUND WATER STREAMS.

It will thus be seen that the "neighbors' rights" are often subject to sad violations. It would, however, prove to be a difficult task to enact a practicable law for the protection of neighbors. If, for instance, a city asks for a prohibition against sinking wells within a certain distance from the ground water plant, then owners of adjacent land, assisted by a competent hydraulic engineer, may prove that the ground water level on their properties as well as over the whole ground water district has been lowered by that water-works; and, secondly, it could be predicted that if a well should be sunk at any place outside of the limit called for by the city this would anyhow produce a lowering inside of the same limit, wherefore the projection wanted would turn out to be an illusion.

A town or a factory can hardly be forbidden to draw water from its wells if this lowers the ground water level of the adjacent country only a couple of inches, but if thus one water-works after another is established, then a general and irreparable scarcity of water may be the result. And how can a complainant lay forth a legally binding proof that the ground water level on his property has really been lowered through this well or that one? It is easy to determine the local action of a well, the "cone of depression" attaining its nearly constant form and extension within a few weeks, but the final influence on the ground water stream above and below the well may not occur before the lapse of some years, particularly where the ground has a heterogeneous composition with strata of different porosity. Before this new state of equilibrium has been attained, other landowners may have established wells some miles further away, bringing new derangements, or may be the ground water level has sunk on account of drainage work, ditching, wood clearing or other measures, which have brought on a decrease of infiltration and of ground water formation.

I am disposed to doubt that the sinking of the ground water level may be legally limited without this leading to injustices and inconveniences of a still worse nature.

According to my opinion the above-mentioned difficulties may be overcome by other means: *raising the ground water level through artificial infiltration of surface water.*

How this is most efficiently to be done, I have tried to indicate in two pamphlets: "Artificial Ground Water," 1900, and "Artificial Infiltration," 1902 (Eng. News, Jan. 8, 1903.—Ed.) In most cases the cleansable infiltration-basin proves the cheapest and at the same time the most efficient means of producing artificial ground water. It consists simply of an open pond in porous ground, where water is let in from the nearest free water course. Such a basin may be shut off, emptied and cleansed like an ordinary filter. On the bottom forms the usual filter film, which takes the major part of the bacteria. It is a filtered, almost perfectly pure water, that sinks through the bottom into the ground, where the last traces of biological contamination disappear, where the temperature is equalized and the character of natural ground water attained. The only difference will be a smaller amount of iron, lime, chlorine and the like.

We may call this the "Swedish system," because Sweden was the first country where towns augmented their supply of ground water by means of cleansable infiltration basins. Figs. 6 and 7 show the application of this method.

In Fig. 6 is shown the same longitudinal section as in Figs. 1 and 4. Below the basins the capacity of the stream and consequently the inclination has increased, which results in a raising of the water level above and below the basins. Fig. 7 shows a cross section with two basins to be emptied and cleaned, each separately.

In most places where the ground water level has been lowered by drawing water from wells it may be raised again by means of artificial infiltration. This latter may be concentrated on one point or distributed on several, according to local conditions.

The cost ought to be distributed among the owners of the water-works, who surely may submit to a taxation of this kind rather than suffer a limitation of their water supply, the much more as the possibility is offered, not only to keep the water supply at a constant capacity, but *even to increase the same to a nearly unlimited extent.* This method enables the saving of considerable sums which otherwise would be sacrificed for the extension or removal of existing water-works.

Therefore artificial infiltration seems to be the best solution of the difficult and important problem of preventing the "progressive sinking of the ground water level."

THE SHONE SYSTEM OF FAN VENTILATION OF SEWERS AT DARLEY ABBEY AND AT LEICESTER, ENGLAND.

A system of sewer ventilation by means of a fan on an extraction shaft and specially designed air inlets at the top of vertical shafts is being introduced in England. The system is named the Shone, after Mr. Isaac Shone, well known in this country as the inventor of the Shone ejector for lifting sewage. Associated with Mr. Shone in this later development and forming the partnership of Shone & Ault,* Civil Engineers, is Mr. Edwin Ault.

The Shone system of sewer ventilation has been installed on a small sewerage system at Darley Abbey, near Derby, England, and also experimentally, but on a working scale, at Leicester, England. It has also been adapted or recommended for use at several other places. The aim of the system is to draw fresh air in at the houses and remove foul air at a point remote from the houses.

THE INSTALLATION AT DARLEY ABBEY.

The parish of Darley Abbey consists of about 200 houses, with a population of 1,000 or so, and two or three mills. The sewerage system and disposal works were built at the expense of a large owner of one of the local mills. The daily water consumption is some 18 U. S. gallons per capita, but the combined sewers are designed to convey six times the dry weather flow, or 108 U. S. gallons per capita per day. The ventilating apparatus is designed to ventilate the street and house sewers, a storage sewer at the pumping station, and also the covered liquefying or septic tanks at the disposal works.* It is claimed, it may be said in passing, that a thorough ventilation of the sewers and tanks favors the bacterial action relied upon for the treatment of the sewage.

The ventilating fan is 15 ins. in diameter, is located at the pumping station and is connected with an outlet or extractor shaft carried some 30 ft. above the ground level.

The house sewers at Darley Abbey are without disconnecting chambers.† Air inlets pipes are provided in the form of a vertical run of pipe connected with the house sewer just outside the house and carried up the side of the house to a point well above the eaves. These inlet pipes appear to be about 4 ins. in diameter and are capped. Air is admitted through a small circular opening or port just beneath the cap. A single air inlet pipe differs from those described. It has a second air port, below the first, provided with a weighted valve which never opens except when a water closet is flushed. At such times air is drawn in through both inlet ports, "and so prevents the water trap of the water closet being unsealed by the flushing of the water closet." It is to be inferred that this particular house is the only one having both an air inlet pipe for the ventilating system and a water closet. It may be added that where disconnecting chambers are placed on the house sewers a simple form of non-return or check valve is used on the air inlet port, which port is placed at the top of a short vertical pipe connecting with the house sewer on the street side of the trap located in the chamber. There are 16 air inlet pipes on the house sewers at Darley Abbey; the one most distant from the fan is apparently about 2,700 ft. away. The sewers are 6 and 8 ins. in diameter.

The power necessary to run the 15-in. fan at Darley Abbey was estimated at 0.4 I. HP. for 1,500 revs. per min., delivering 500 cu. ft. of air per minute with 2-in. water gage pressure. This would provide 0.1 cu. ft. of air per minute per person for a population of 1,200, or a total of 120 cu. ft., and allow 380 cu. ft. additional for leakage into the pipe system and for ventilating the tanks at the disposal works. Interesting information on the volume of air extracted from the sewers at Leicester, the amounts drawn through the inlets and sucked in through leakage points is given below.

EXPERIMENTS ON A WORKING SCALE AT LEICESTER.

The experiments with fan ventilation of sewers at Leicester are particularly worthy of attention because they were carried out and have been described‡ by Mr. E. George Mawbey, M. Inst. C. E., Borough Engineer of Leicester. Ar-

*47 Victoria St., Westminster, London, S. W., England.

*The sewerage and sewage disposal system at Darley Abbey, together with the ventilating system, were described and illustrated in the London "Contract Journal" for Nov. 25, 1903. The article included a discussion, largely theoretical, of the local problem of sewer ventilation.

†A common if not well nigh universal practice in Great Britain is to cut off direct connection between the house plumbing and the street sewer by inserting a chamber, open to the exterior air, in the line of the house sewer. The outlet from this chamber is trapped by means of a water seal. The whole device is frequently called an intercepting trap.

‡"Experiments on Shone's System of Sewer Ventilation at Leicester." A paper read before the meeting of the Incorporated Association of Municipal and County Engineers at Shrewsbury, England, July, 1904. The paper was published in the London "Contract Journal" of July 20 and in the London "Surveyor" for July 27, 1904.

rangements for the experiments were made in July, 1902, the city agreeing to install the system for a small district, and Shone & Ault agreeing to pay a part of the capital outlay.

The district includes an area of 2½ acres, 80 six-roomed houses occupied by the artisan class, 891 ft. of 12 and 9-in. pipe sewers on grades ranging from 1 in 36 to 1 in 150, and an aggregate length of 1,749 ft. of house sewers mostly 6 ins. in diameter. The street sewers, exclusive of manholes and the like, have a holding capacity of 661 cu. ft. and the house sewers of 304 cu. ft., making a total of 965 cu. ft. The sewers were laid in 1896-7, apparently with more than ordinary care to prevent leakage. The joints of the street sewers were made with Portland cement and of the house sewers half with Portland cement and half with clay, but in each case the house drain joints were surrounded with a band of clay puddle 8 ins. wide. At most of the junctions of street and house sewers there is an inspection chamber, with brick walls and a stone cover. The street sewers are flushed about once in three weeks, some by means of hose connected with street hydrants and one by means of a water cart.

None of the house sewers have disconnecting chambers, but for the whole 80 houses there are 27 4-in. cast-iron ventilating pipes, carried up above the eaves at the rear of the houses. These pipes are connected with the heads of the house sewers. There are from one ventilating pipe per house to one for six houses. The pipes were jointed with red lead. Each pipe, during the first of the tests, was provided with an air inlet, the various inlets ranging from 5-16 to 1 in. in diameter.

The street sewers connect with larger brick sewers, from which they were separated before the tests by lowering gates provided for use when the sewers are being flushed.

At the upper end of the sewers experimented on, a chamber was built of brick in cement mortar, and in this there was placed a 15-in. Sirocco fan, driven by an electric motor working at 700 revs. per min. A short length of 18-in. sewer pipe connected one side of the fan with a flushing manhole. The other side of the fan was first connected with a 6-in., and subsequently with a 9-in. steel outlet shaft 40 ft. high. To make this connection a zinc pipe was used, 7 ins. square at the fan, and, eventually, 9 ins. in diameter at the base of the shaft.

During a five days' test begun on April 27, 1903, hourly readings were made of a fixed anemometer in the 6-in. outlet shaft (actually 6 5-16 ins. in diameter or 31.29 sq. ins. in area), and a daily reading during ten minutes at each of the 27 inlets. The averages showed that through the main shaft 275.1 cu. ft. of air per minute passed at a velocity of 1,266 ft. per minute, while through 27 inlets an apparent total of 31.17 cu. ft., or an average of 1.15 cu. ft. per minute, passed at an average velocity of 29.3 ft. per minute. This gave an average of 0.39 cu. ft. per minute for each of the 80 houses. The air inlets had areas of 5-16 to 1 in., and a combined area of 10.728 ins. This was one-third the area of the outlet shaft, while the registered volume of air entering the inlets was only one-ninth that passing through the outlet. It was noted, however, that on about seven inlets per day (not always the same inlets) the anemometers did not register. It was assumed, and in fact other tests, with one exception, indicated that a volume (or velocity) too small to be registered passed the inlets. This would account for only a small part of the discrepancy, indicating a large suction of air into the sewer through the joints at manhole covers, inspection chambers and through other openings.

On finding that the discharge of the fan at the street level instead of at the top of the shaft greatly increased the volume of discharge at both the outlet and the inlets, the 6-in. outlet was replaced by a 9-in., the fan connected and further tests made. The advantage of the 9-in. over the 6-in. outlet was established, the inlet volume of air being increased and the anemometers at all the inlets made to work. It was decided to enlarge the inlets. The sectional areas were therefore increased so as to range from 1½ to 7¾ sq. ins. in area and to aggregate 75.258 sq. ins., or 89% of the area of the 9-in. outlet shaft. It was found that under these conditions 752 cu. ft. of air per minute, at a velocity of 1,284 ft. per minute, was now discharged through the outlet shaft and 324.53 cu. ft. per minute was drawn through the inlets, at an average velocity of 226.2 ft. per minute.

The latter results gave an average of 12.02 cu. ft. per minute per inlet and 4.06 cu. ft. of air per minute for each of the 80 houses. This was considered, Mr. Mawbey states, "vastly greater than was required," and showed that the fan "was capable of dealing with a much greater district."

It had been learned that the cost of operating the fan, in the experiments thus far made, was too high for continuous service. Various tests were therefore made to determine the air movements and the cost of running the motor with additional air drawn from the main sewer outside the district previously under test. During the final test 746 cu. ft. per minute was drawn from the adjoining district and only 142 cu. ft. per minute from the original district. Of the 142 cu. ft. a total of 106.08 cu. ft. per minute came through the 27 air inlets on the house pipes, giving an average of 3.92 cu. ft. per inlet and 1.33 cu. ft. for each of the 80 houses. This [assuming equal distribution through the house sewers not provided with air inlets.—Ed.] means that the air in the private drains was changed with air drawn direct from the atmosphere 502 times per 24 hours, or about once every three minutes, whilst the air in the ventilated sewers was, roughly speaking, changed 300 times per 24 hours, or once every 4½ minutes.

Deducting from the total electric current consumption the proportionate amount required for the air drawn from outside the district, there remains 1.92 Board of Trade units per 24 hours used to ventilate 80 house sewers with a population of 356, as compared with 9 to 12 units before sewer air was drawn from outside the district. At 1d. or 2 cts. per unit the 1.92 units per 24 hours would cost at the rate of £8 3s. 11d., or $39 per 1,000 population per annum, which would be about 2d., or 4 cts., per capita. Mr. Shone claims that 0.5 cu. ft. of air per house per minute, or 0.1 to each person, is sufficient, as compared with the 1.33 cu. ft. upon which the above unit prices are based. With 0.5 cu. ft. per minute the air in the house sewers would be changed about once in ten minutes and the cost of the electric current would be reduced to £2 7s. 4d., or $11.50 per 1,000 population per year, or a little more than a cent a person a year.

Numerous air analyses were made to show the effect of the ventilation upon the amounts of CO_2 in the sewers. At the time of the last experiments described, or on April 30, 1904, when the volume of air being drawn into the sewers was an average of 1.33 cu. ft. per minute per house, and when the temperature of the sewer air was 61°F., and of the outer air 62°F., it was found that one sample of air from a manhole in the ventilated district showed 13.84 and another 12.65 parts of CO_2 per 10,000, giving an average of 13.24 parts as compared with 3.56 parts found in the outer air at the same time and in the same vicinity. Four sets of analyses on May 11, May 17, and June 10, 1904, under conditions similar to those just cited, show 3.9 parts per 10,000 of CO_2 in the external air, and from 8.36 to 15.51, with an average of 13.11 in the manholes. Winter analyses, with low temperatures and larger volumes of air drawn through the sewers, showed better results, but the current expenditure on those dates was considered prohibitive. The worst air found in manholes on sewers outside the specially ventilated district showed from 20.62 to 24.98 parts of CO_2 per 10,000, and an average of 15.95 parts. This was on May 11, 1904, in dry weather, with a sewer temperature of 62°F. and an average outside temperature of 66°F. The sewer was 12 ins. in diameter, and adjoined the ventilated district, and was like the sewers in that district in type and period of construction, with closed manhole and lamphole covers, and no ventilation except by the 4-in. private ventilating pipes, there being no ventilating shafts upon the sewers.

Analyses made on June 30, 1904, of two samples of air from an "old defective 15-in. brick sewer," having no ventilation "except by a few private ventilating pipes and soil pipes" showed an average of 20.40 parts of CO_2 per 10,000. The temperatures at the time were 69°F. in and 75° outside the sewer.

Mr. Mawbey was convinced by the experiments that it was impossible to determine the most efficient proportions for the individual fresh air inlets by theoretical calculations. Instead, he recommended a terminal for the inlets "so designed that after fixing it could be adjusted to admit the volume required—this being ascertained in each case by an anemometer test." Such a terminal has been devised by Shone & Ault.

In conclusion, the author stated that when the system of ventilation was first laid before him he questioned its practicability. After tests extending over two years he was able to pronounce satisfactory the ventilation of the district experimented on. Not only had there been no siphoning of house traps, but the "vacuum in all parts of the system had been too small to be registered by a water-gage, although many attempts" to obtain readings had been made. The experiments certainly go to show that, by the Shone system, a sufficient quantity of fresh air direct from the atmosphere can be supplied into, and circulated through, soil-pipes, drains and sewers, to dilute the air therein to any extent which may be necessary, and, according to the results obtained in this practical test, at a cost which, having regard to the importance of efficient ventilation, cannot fairly be considered to be prohibitory.

In the course of a discussion on the paper, Mr. Mawbey stated that in experiments on natural ventilation of sewers carried out by him during a period of five years he had found the air in pipe sewers more foul than in main [brick?] sewers having a good flow.

Some comments on the ventilation of sewers by fans and specially designed air inlets may be found in our editorial pages.

AN INGENIOUS AND EFFECTIVE AIR-LIFT PUMP.

To force water to a height of 300 ft. with an air pressure of less than 40 lbs. per sq. in. seems at first sight an impossibility, because water pressure due to a head of 300 ft. is 130 lbs. per sq. in. Nevertheless this can be, and has been, done by the novel pump that we are about to describe. We are informed that the Patent Office at first rejected the application for a patent on this pump, on the ground that it would be non-operative; and, as we doubt not that many engineers will likewise be inclined to ignore the claim that water can be forced up several hundred feet of pipe with a nominal air pressure, it seems worth while to explain the elementary principles involved.

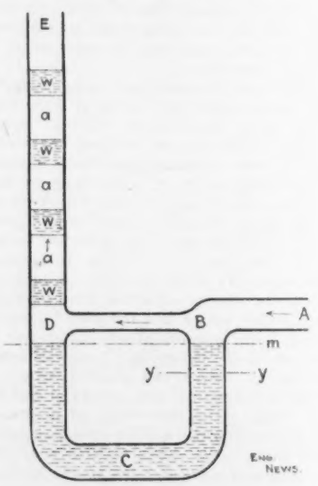


Fig. 1. Model Showing the Principle of a Novel and Ingenious Air-Lift Pump.

Fig. 1 shows a U-shaped tube filled with water up to the level m. Suppose compressed air to enter at A, at a pressure of, say, 10 lbs. per sq. in. We should expect this air to traverse the open tube in the line of the arrow from B to D, and then escape up the open tube D E to the atmosphere. This, in fact, is what the examiner at the Patent Office believed would happen, nor were the attorneys for the patentee able to con-

since the examiner to the contrary by argument; due, we believe, to failure on the part of the attorneys themselves to understand the philosophy of the action of the pump. It was certain that the pump would work, for it had done so on a large scale in a mine where it had been installed. Furthermore, a glass model, as shown in Fig. 1, could be made to deliver water at E, merely by blowing at A. The explanation of the phenomenon, as it seems to us, is as follows: Air entering at A has a pressure of say 10 lbs. per sq. in. when it reaches the space B above the surface of the water. In passing through the tube from B to D the friction of the air on the sides of the tube reduces its pressure, so that when the air reaches the space D it has a pressure of, say, 9¾ lbs. per sq. in. We have, then, a pressure of 10 lbs. per sq. in. acting downward upon the surface of the water at B, opposed by a pressure of 9¾ lbs. per sq. in. at D. The result is that the water in the tube descends on one side to a level y y, while it ascends on the other side correspondingly. In round numbers the pressure due to the weight of a column of water is ½-lb. per sq. in. for each

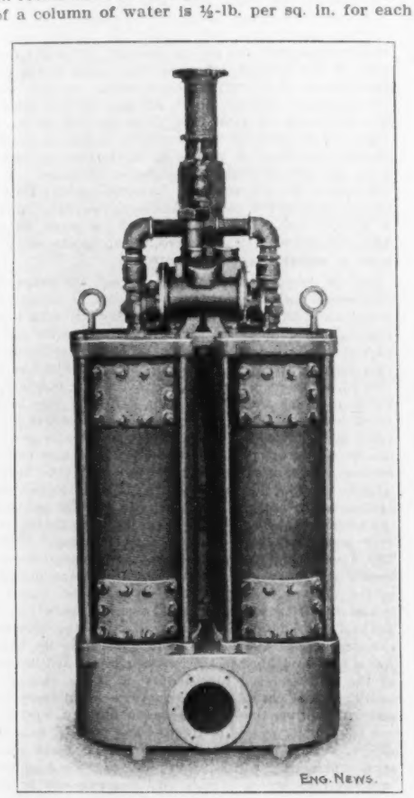


Fig. 2. One Design of a Novel Double Air-Lift Pump.

foot of height of column; hence a difference of ¼-lb. per sq. in. between the air at B and the air at D would result in a difference in level of the water surfaces amounting to 6 ins. in the opposite legs of the U-shaped tube. In other words, the water surface at B would descend 3 ins. and that at D would rise 3 ins. This is what would occur were it not for the fact that when the column of water rises at D, it shuts off the air coming through the tube D B. The instant that this occurs the water begins to rise more rapidly, due to the now unbalanced pressure; and, almost immediately, the air in the pipe B D forces its way under a portion of the rising column of water in the pipe D E, thus separating a piston of water, w. A repetition of this process occurs until the pipe D E is filled with alternate pistons of water, w, and pistons of air, a. The air pistons, as they ascend, are constantly expanding, due to the decreasing weight of water above them. Thus, much of the energy of the compressed air is expanded in doing useful work.

Now we can see why it is that an air pressure of 40 lbs. per sq. in. at the base of a column of water in the delivery pipe can support water and air pistons in a pipe 300 ft. high; for, in fact, the compressed air is not lifting a solid mass of water 300 ft. high. A pressure of 40 lbs. per sq. in. can lift a solid mass of water only a trifle more than 17 ft. high; hence, it follows that if we were to add together the lengths of all the water pistons in the pipe 300 ft. high, we should find the sum of their lengths equal to not more than 17 ft. In fact, it would be considerably less, for the friction of the ascending air and water on the sides of the pipe would act exactly like an additional weight of water, and thus reduce the actual weight of water in the pipe.

In the model, shown in Fig. 1, there is no valve in the pipe, B D, but in practice such a valve is inserted, for with a valve there it is possible to throttle the air so as to get a difference of pressure between B and D that will produce the size of water and air pistons best suited for any given size of delivery pipe and lift under any given air pressure from the compressor. For a continuous delivery of water it would be necessary to submerge the model in water and to provide an intake valve. In practice it has been found desirable to combine two of the elements shown in Fig. 1, so that one may be filled by "suction" while the other is being discharged by the air pressure. An automatic piston alternately connects each of the pump chambers with the exhaust and with the compression end of the air compressor. This necessitates two lines of pipe to the air compressor, but it results in economy of air as well as in ability to work with a pump that is not submerged. The general appearance of a double pump is shown in Fig. 2.

The first published mention of the pump that we have just described is to be found in the Journal of the Assoc. Eng. Soc., Oct., 1900, p. 201, in an article by Edward A. Rix. No satisfactory description is given of the operation of the pump, but a table of tests of its efficiency is given. Using a delivery pipe 4 ins. in diameter and with a lift of 105 ft. Mr. H. C. Behr, M. Am. Inst. Min. E., made 21 tests under varying air pressures. We have selected some of these tests as follows:

Air pressure (above atmosphere) lbs. per sq. in.	Efficiency of pump.	Efficiency of compression.	Total efficiency.
41	42.5%	69.4%	25%
33¾	48.1%	73.8%	30.2%
29½	40.6%	76.3%	26.3%
29⅛	46.1%	76.7%	29.9%
24⅛	39.8%	79.5%	29.9%
24⅛	50.2%	79.5%	33.9%
23¾	40.4%	79.8%	27.4%
19	36.4%	82.6%	25.5%
14½	24.1%	85%	17.4%

It will be noted that the efficiency of the pump itself is high at all pressure except at the lowest pressure used, namely, 14½ lbs. The tests, however, show variations not accounted for by Mr. Behr. The last column of total efficiency was calculated by multiplying together the percentages in columns two and three and deducting 15% for friction of the compressor mechanism. Obviously the total efficiency may be materially increased by using a two-stage compound condensing air compressor plant.

This type of pump is especially adapted for mine pumping and for deep well pumping. Because of the fact that a low air pressure will force water up through many hundred feet, it follows that a comparatively light discharge pipe can be used, effecting a great saving in the cost of installation. For pumping the waters of coal mines which are usually charged with sulphuric acid, it would be practicable to use cheap bored wooden pipe, instead of expensive and heavy iron pipe lagged with wood. Not only can a light piping be used, but the pump itself may be correspondingly light, thus effecting a material saving in first cost, and in transportation. It should be always borne in mind that the pressures in the delivery pipe and in the pump can not exceed the pressure of the compressed air; furthermore, that there can be no water hammer.

The air compressor itself need not be a large one, provided the quantity of water is not large, even though the lift be a very great one. This is a feature especially worthy of consideration in mining work.

As above stated, the pump is not submerged as in the Pohlé air-lift system, and for this reason a well may be pumped down till it is practically dry. But, as is well known, when a well is pumped down low the flow of water into it is increased, due to the greater head of outside water.

One of these pumps with a 1½-in. air pipe and a 4-in. discharge pipe is said to be in operation in San Mateo County, Cal., pumping 200 gals. per min., with a lift of 210 ft., using a pressure of 30 lbs. per sq. in. Another of these pumps was exhibited in New York City, Oct. 22, at the American Tract Society Building, where 100 gals. per min. were lifted 300 ft., using air pressure of 38 lbs. per sq. in.

The inventor of this pump is Mr. D. W. Starrett, of Oakland, Cal., and it is manufactured by The W. G. Leale Co., 119-121 Mission St., San Francisco, Cal. Mr. W. E. Crist, of 182 Broadway, New York, is the Eastern representative of the company.

SIMPLE METHODS IN WARSHIP DESIGN A NECESSITY.*

By George W. Dickie, M. S. N. A. & M. E.†

At the society's meeting of 1899 I presented this subject in order to relieve my mind somewhat in regard to it. In the discussion of that paper there appeared to be a unanimous opinion that warship fittings were getting to be too complicated.

The modern warships, and I think also the men who design and build them, may be classed as complicated combinations of compromises that have come to be so involved in structure and function as to be quite incomprehensible even to the experts themselves, whose desire to leave nothing out that could possibly be brought into the design, obliges them ever after to be inventing reasons why such devices ever found a place in the design of a warship.

The reasons I gave in 1899 for the complicated conditions on war vessels apply with equal if not greater force now. These are:

First.—Uncontrolled growth of new devices for doing the many things for which mechanism is required on these vessels, without the new devices being considered reliable enough to supersede the old. Hence duplication, and, in many cases, triplication of apparatus for doing one thing for which one good device alone should be used.

Second.—The system of divided control over the work renders it impossible to have a homogeneous design to begin with.

Since 1899 additional causes of complication have been brought into play. Special experts in certain lines of work have been given charge of the work in which they are expert, thus bringing about a struggle for room to place all the devices the experts think to be necessary to make their specialties complete. To make this possible, specifications have been prepared and cleverly worded to cover the unknown requirements of the future, which, when finally worked out, produces two results—a tangled mass of complications on the ship and a financial complication to the contractor.

The item of ventilation on ships now building and recently completed has cost on an average about three times what it cost on similar vessels completed three or four years ago, the specifications being worded the same. This one feature in the increasing complication has involved the shipbuilders in a loss on all the ships building when the change was effected of somewhere near one million dollars without any corresponding benefit resulting to the vessels thus hampered with a network of air ducts and electric fans.

The condition on these ships has now reached such a stage of complication that a large number of experts is found necessary to get the thousands of intricate devices tuned up for inspection so that everything will function as specified; and to keep them in that condition, is, I am afraid, a task beyond the ability of the officers and men in charge of this modern puzzle.

It is the duty of the naval architect and marine engineer to set about unraveling the tangled mass of intricate contrivances on board our modern warships, doing away with all that is unnecessary, and arranging what is absolutely necessary in such order that it can all be understood by the men who have to work it and keep it in order, and so that anything needing repair can be gotten at without destroying everything surrounding it to do so.

I have been urged to take this matter up again by many naval officers in positions of responsibility on our warships. These men feel that the increasing complication and multiplying diversity of function sought to be reached by mechanical contrivance have become a positive dread to the officer who is held responsible for it all operating in the proper way, and at the proper time, just as its designer said it would do if kept in proper order.

Since first proposing to incorporate into the structural features of the ship a central passage, through which

*Condensed from a paper read before the Society of Naval Architects and Marine Engineers, at New York, Nov. 17.

†General Manager Union Iron Works, San Francisco, Cal.

would be carried on all the business of managing and controlling the many important operations that are continually being carried out on a war vessel, I have been continually adding to the varied functions of such a feature in the design. That this passage is the most important feature in the plan I am presenting will appear as its connection with all the work of the ship develops. I have designed it as one water-tight compartment, without any subdivision between the bulkhead at the forward end, about 50 ft. from the ram, and the automatic door just forward of the steering gear compartment. I have given this much thought and cannot conceive of any damage, short of total destruction of the vessel, that would impair the integrity of this compartment.

DRAINAGE.

The first item I propose to consider is that of drainage. In 1893 I proposed, in a paper read before the Engineering Congress at the Columbian Exhibition, to provide for all drainage in the structural arrangement of the double bottom. I am more than ever in favor of so constructing the framework between the outer and inner skin as to provide a continuous well that will receive the drainage of the whole ship, except that of the double bottom itself.

Referring to the accompanying general midship section, I have shown two vertical keel plates instead of one, placed 24 ins. apart. The center plate of the inner bottom is dished 6 ins., forming a gutter waterway on each side of the middle line bulkhead. This is carried the whole length and covered with a perforated plate forming a continuous strainer of great area. A sufficient number of valves are fitted in the dished plate in each compartment to give a clear area from each main compartment into the main drainage well equal to the total pumping capacity. These valves would be operated from the floor of the central passage described further on. The main drainage well is in itself a water-tight compartment, all openings into it being controlled from the central passage. Its size is 24 by 30 ins., being large enough to admit a man for inspection and painting. We have thus provided, as far as horizontal drainage is concerned, a complete system without adding anything to the general structure of the vessel, and it is a real drainage system into which every compartment above the inner bottom naturally drains, requiring only some simple means of lifting the water that drains into the space between the vertical keels, and discharging it overboard.

Originally, this work was performed by hand lift pumps, operated by men working on cranks or pump brakes and drawing the water through a simple vertical suction, but, owing to the power employed, very limited in capacity; there was also considerable waste of the small power available through crude mechanism and by lifting the water to a deck usually much higher than the level of the water outside. These hand drainage pumps, as fitted to naval vessels, were usually made to act also as force pumps to be used in case of fire, thus very much reducing their efficiency as drainage pumps. When steam became the means of propulsion in naval vessels the hand drainage pump was supplemented by a drainage or bilge pump worked from the engines. This required that water be taken from any part in the length of the ship to the engine room before it could be lifted up and discharged, and this introduced horizontal pipes and manifolds. Then independent steam drainage or bilge pumps came into use and these were placed in the engine rooms, still further adding to the horizontal complication of piping and valves. These pumps are also fitted as fire pumps, making them the worst type of pump that could be devised for drainage purposes. To this has been added another class of pump called auxiliary feed, fire and bilge pumps, forming another combination worse than the other, the three functions sought to be combined being as far apart as they could possibly be in mechanics. To get the water to all these varied machines in order to be lifted to the level of the water outside the ship involves the designer in a mass of horizontal piping, which, coupled with the manifold system, converts the space between the working floors and the inner bottom into a perfect network of piping, that is very hard to get at, and, in consequence, very difficult to keep in order. Recently, I counted 51 drainage pipes in the forward end of the engine room in a new battleship, and there would have been more if space could have been found for them.

I would, therefore, propose to abolish the whole present system of horizontal piping, and all manifolds and emergency connections to circulating pumps, with all their numerous connections and valves. I would have no such unnatural combination as a bilge and fire pump or a feed and bilge pump—the two functions are entirely opposed to each other. A good bilge or drainage pump is of no use as a fire or feed pump, and a good fire or feed pump is the worst possible form of pump for drainage purposes.

I have thought much about the best type of drainage pump, and have finally come to a settled conviction that the type of pump proposed in the paper read by me before this society in 1899 best meets all the conditions of the special service involved in a simple drainage plan suitable for a naval vessel. This is simply a single-acting jackhead lift pump, which will take air. I have, therefore, arranged on the port side of the central passage, four pumping stations, formed by widening the passage at four points enough to avoid obstructing the passage by the pumps and their operating gear. In each pumping station would be installed a set of three simple jackhead lift pumps, having 12-in. diameter buckets and 20 ins. stroke, operated by a 12-HP. electric motor. At full speed the pumps would make 40 strokes per minute. The total lifting capacity of the four pumping sets would be 1,100 tons of water per hour, or 4,800 gallons per minute. The arrangement of suction and discharge pipes is clearly shown on the midship section, and consists of a simple vertical suction pipe from each pumping station extending down into the drainage well, controlled by a valve above the inner bottom. From the valve chamber on each side extend branches with the valves for pumping out the double bottom compartments. The stems of the main and side valves are extended up through the floor of the central passage, where they would be operated as required by the man in charge of drainage. The discharge pipe extends directly up to the protective deck and over to the side of the ship between two beams, where it discharges through a non-return valve.

The whole drainage system requires: 60 ft. of suction pipe, 100 ft. of discharge pipe, and 16 valves. This replaces on a similar ship fitted under the present system of drainage: 3,738 ft. of piping, in 324 pieces, 444 fittings and flanges, 124 valves, 113 bulkhead fittings, and 62 McComb strainers; all of which require the making and keeping tight of 1,225 joints. Besides there is operating gear for valves all over the vessel often far from the valves, both in a vertical and horizontal direction.

The whole drainage would be managed from the central passage, the plates for all valves being on the floor, as well as sounding tubes. The dished form of the middle line plate for the inner bottom covered by a strainer plate extending through the whole length of the drainage well, which is practically the whole length of the ship, prevents all dirt, except what will pass freely through the pumps, from getting into the well.

VENTILATION.—The problems involved in the ventilation of the modern warship are probably the worst that the naval architect has to deal with. The great power to be developed on these vessels and the high temperature of the steam carried means that more than half of the middle length of the ship under the protective deck is full of heated surfaces to something like 300° F., making the ventilation problem for the middle part of the ship more that of removing hot air than that of supplying fresh air.

Some time ago, I proposed for one of the high-powered new cruisers, fitted with water-tube boilers, to encase each of the boilers with an outside casing, having an air space of about 2 ins., between the boiler and this outer casing. Into this space on the top of the boiler I proposed to blow the air for combustion, with arrangements to insure that the air current went over the whole surface on its way to the ash pits and to the openings above the grates, the outer casing to be made portable and provided with doors where the boiler casing had doors. All the radiant heat from the boilers would thus be taken up by the air for combustion and added to the furnace temperature instead of, as now, adding greatly to the difficulties of ventilation. This proposition was thought very good by the Bureau of Steam Engineering, but disapproved on account of the added weight. This added weight for the twelve boilers was about 26,000 lbs. On this same vessel, to solve the problem of protecting the protective deck above the boiler compartments from the radiant heat of the boilers required another bureau to build a false deck some 18 ins. below the protective deck with special ventilation arrangements to maintain a current of cool air between the false work and the protective deck. This work weighs 32,500 lbs., and still leaves the hot air below it to be dealt with by other means:

The artificial ventilation on the recent United States naval vessels is a departure from the older methods, the vessel being divided up into many systems each providing ventilation for a certain section of the vessel and proportioned in capacity to the requirements of that section, the principal object of this arrangement being, I think, to avoid cutting through the main bulkheads with large air ducts, requiring as they do automatic valves, and perhaps less loss through friction in the longer ducts, necessary where there are fewer units in the installation. The objections to the new method are, that if any ventilation is required over the whole ship, every fan must be in operation to get it, although the amount required may be very little; the independent system being fitted over the whole length of the ship requires that inlet cowls be fitted all over the upper decks. At the ends of the vessel this presents many difficulties which will render some of the systems inoperative when most needed. I find on the forward upper deck of a battleship just completed, besides a number of small cowls, one 36-in. cowl on each side, just forward of the turret. In very ordinary weather, when the hatches would be closed, these cowls would have to be removed and the water-tight covers fitted on the openings; they must also be removed to operate the turrets, and in action they would have to be removed and the battle covers fitted. These openings supply air to the fans that ventilate the berthing spaces forward of the turrets on that vessel. Thus, at the time when the hatches are closed and air ports are closed, and ventilation is most required, it is entirely shut off. All ventilation aft on the same ship is in the same condition, when the circumstances are the same. Ventilation of engine rooms is rendered difficult by having to get air through engine room hatches generally far too small to let the hot air escape.

I propose to solve the ventilation problem, like other problems, through the central passage. This passage widens to 15 ft. between frames 35 and 40. In this widened portion and between frames 37 and 38 an air trunk 12 ft. extends to the upper or boat deck, behind the shield of the conning tower. The upper part under the bridge receives air through adjustable louvres fitted on all sides. In very rough weather when the seas might reach the bridge deck, the louvres might be closed on the weather side. At the base of this fresh air trunk in the widened part of the passage, there would be installed six electric fans, each having a capacity of 15,000 cu. ft. of free air per minute, or 90,000 in all. The air trunk is divided into six compartments at the base to provide an independent suction for each fan, each provided with an air-tight shutter to close the opening when its fan is not running. The fans would deliver directly without casings into the passage. About one ounce air pressure would be maintained constantly in the passage and the necessary number of fans kept running to maintain that pressure. The central passage forms the main air duct for the whole ventilation of the ship. All compartments requiring artificial ventilation, except the boiler compartments, will receive the air necessary for that purpose from the central passage. From the roof or sides of the passage, air ducts will extend to the determined point of delivery. This includes the main engine rooms and the dynamo rooms. All openings into the ducts will be closed by water-tight gates operated in the passage. These gates or valves will be opened or closed by the man in charge of ventilation in the passage, on order from the compartment or room to be ventilated. In living spaces the air would be delivered not far from the floor or deck of the compartment being ventilated, through a special type of louvre arranged to stand close to bulkhead and with slats to direct the air to any part of the room or compartment as required.

For all living spaces, the outlets from the central passage would be small, so that each room or compartment would have its own independent connection with the air supply. This is necessary in connection with another part of this arrangement, whereby the steam heater arrangement or radiator system is combined with the ventilation. At each outlet taking air to living quarters and berthing spaces a special radiator is fitted. This is combined with the shut-off valve, being a double coil, circular in form, made without joint, and so arranged that the air on its way through the outlet must pass over the surface of the pipe forming the coil and thus becomes heated. This forcing the cold air over the steam heated surface of the radiator would be very effective and enable the surface, in proportion to the space to be heated, to be very much reduced from that of the ordinary radiator. The amount of steam applied to the radiator would be regulated by the man in the central passage in charge of the heating system, as ordered from the rooms or spaces requiring hot air. Each room or space can thus be kept at the temperature required by the occupants, the steam pipes to and the drain pipes from the heaters would all be installed in the central passage and in charge of the man assigned to the duty of taking care of the heating arrangements. This removes a lot of steam pipes and fittings from the living spaces in the ship, where they are a continual source of trouble, and usually, to a large extent, very difficult to get at for repairs, and placing them where they will be always in sight, and in unobstructed lines where repairs and renewals can be made with the least trouble and expense.

Besides the simplicity of this arrangement, there are many other advantages. The number of fans in operation will always be just that required to keep the necessary air pressure in the passage. This, of course, will always be considerable, as the main engine rooms and dynamo rooms will require a steady volume of considerable amount; but as these compartments will receive the fresh cold air on their lower floor levels, making all hatch and casing outlets upcasts for the discharge of hot air, better results will be secured with a less volume of air blown in than with the present system. The upper decks will be entirely relieved from ventilation pipes and cowls, which, in many cases, as already pointed out, have to be unshipped and closed up when most required. The whole ventilating and heating machinery is located where it can all be cared for and kept in good order with the minimum amount of work.

INTERIOR COMMUNICATION.—I expect to be able to simplify by means of the central passage much of the means of interior communication. Much of it can also be simplified without any special feature in the ship construction being introduced. Doors and hatches come under this designation.

I have never been able to discover the necessity of installing complicated mechanism, either electric, pneumatic or hydraulic, to operate a door or hatch. There is no special difficulty in making such a door or hatch that will work satisfactorily and go through all the prescribed tests and that will continue to do so, if kept in proper

order and under the care of an expert, but the location of the most important of these doors being in the dust and grit of the fire rooms, their chance of being properly cared for is very small indeed. I have studied the power operated door question very thoroughly, and, I think, have succeeded in making a door as simple as a power operated door that can be operated at a distance can be made, but I have always considered the time and thought spent on the problem as, in a certain sense, wasted, as all such devices are bound in a very short time to be discarded, simply because they need so much care and attention and they are not really necessary, and because of that fact are more or less neglected. When it is understood that a door or hatch can be operated well enough if its complicated mechanism fail, much time will not be spent in caring for the mechanism.

TELEPHONE AND TELEGRAPH COMMUNICATION.—Since the advent of the telephone, speaking tubes have been discarded in all modern buildings, and they should also be discarded in the modern warship. The telephone has been brought to perfection so as even to speak out loud, that there need be no doubt as to its reliability on board ship. The number of voice tubes now required on one of our armored cruisers, if placed side by side with one inch space between, occupy a width of 60 ft., whereas the wires for as many telephones could be installed inside one of them.

The central telephone station would be installed in the central passage, directly under the conning tower, where there would be a switchboard for making connection from any part of the ship to any other part of the ship. Here also orders would be received regulating all matters under control in the passage. There would always be one man on watch in the central station, who would have a messenger to carry orders to any of the men in charge of work in the passage. It might be necessary to run the telephone lines from the bridge to the engine rooms and from the conning tower to the turrets direct, instead of through the central station; but all other telephone service would go through the central station. From all points having telephone connection the wiring would be carried as direct as possible to the central passage and horizontal leads carried in the passage.

The call-bell system would be installed very much as it is at present, except that a complete telephone system, as described above, would very much reduce the number of call-bells, the call for personal service being about all that would be necessary.

Engine-room telegraphs and revolution indicators should be limited to one kind, and whether fitted as mechanical or electrical, they should be the best that could be devised. The mechanical instruments as now fitted, I believe to be the best and most reliable, and when direct telephone communication is also provided between the bridge and engine rooms, orders for any and all varieties in speed can be readily communicated. The mechanical revolution indicator simply continues the motion of the engine shaft to the bridge. The small shafts for that purpose would pass directly from the engine rooms into the central passage and run in a direct, straight line to the armored tube under the conning tower and through that to the stations where engine room telegraphs are installed. The dials for engine revolution indicators would be a part of the telegraph stand and would be properly illuminated. All wire leads for the engine room telegraphs would be carried in straight lines from base of the armored tube to the engine rooms through central passage.

The wiring for battle order transmitters and receivers, if such instruments are thought to be indispensable, would be carried down through the armored tube, which I may state here should be large enough to install all work to be carried through it on its walls, leaving a clear space in the center sufficiently large for a man to ascend from the central passage to the closing plate at the conning tower floor for examination and repair. From the base of the tube the wires, bunched together or in cables, would be carried to points directly under the instruments they are to connect and pass up from the passage in as nearly vertical leads as possible. This gives less chance of their being destroyed in action, and for nearly their whole length they are open to view and readily got at. Other means of communication, such as fire alarms, calls to quarters, etc., except thermostats, would be operated from the central passage by telephone order. This would save much wiring and all that fitted would be vertical.

STEERING GEAR.—I have preferred to use electric steering gear, not because I think that the steering can be better done by electric power than by either steam or hydraulic gear, but because I think steering can be equally well done by properly designed machinery by any one of the three methods named, and because all auxiliaries on board naval vessels are now operated electrically except the steering gear and windlass, yet these two exceptions involve the installation of steam pipes from one end of the ship to the other. To operate the steering gear by electric power presents a no more difficult problem than the training of a turret, perhaps less, and electrically operated turrets have replaced, in our navy at least, both steam and hydraulic power for that purpose. The windlass can just as well be operted electrically as a boat crane. With the steering and anchor gear operated by motors, no steam pipes would be required outside of the main engine and boiler room enclosures. These steam pipes, especially those running aft to the steering gear, which are constantly in service when the vessel is under way, are not only troublesome to keep in order but cause considerable heat, which, added to that caused by the steam engines in the steering room, renders special ventilation provisions necessary.

The cables between the controller and the motors on the steering gear would be carried direct along the central passage to the motors. From the rudder head a shaft would be carried along the roof of the central passage, and up through the armored tube to each steering station operating helm indicators, which I would propose to make with vertical arms, the arms being the full height of the stand, or, say, about three feet. This would give a large movement at the end of the arm, showing the slightest movement of the rudder. The hand steering gear would be arranged, as usual, aft.

FIRE AND FLUSHING ARRANGEMENTS.—Fire and flushing arrangements and fresh water supply requires some consideration of the pumping appliances to be provided for such a vessel, and in the scheme now being considered I propose to do away with all pumps such as auxiliary feed, fire and bilge pumps, for reasons already set forth in connection with drainage, and adhere strictly to providing pumps with one duty to perform, and designed expressly for that duty. All steam pumps I propose to install in a pump room, extending across the vessel between the main engine rooms and the after fire rooms. The longitudinal center line bulkhead would divide this space into two compartments; the pumps installed in each of these compartments would be duplicates of each other. The auxiliary condensers with their air and circulating pumps would be installed on the outboard side of each pump room; they would also take the steam from the dynamos above. There would be a special fire pump in each pump room, designed for the purpose of maintaining a pressure in the fire mains of say 250 lbs. per sq. in., and for the vessel we are considering, to have a capacity of 600 gallons per minute. These pumps would take water from a sea stool or chest in the pump compartment and deliver into a fire main in the central passage extending practically its whole length. This main would be 7 ins. in diameter, the diameter being reduced toward the ends as branches were taken out. The branches or stand pipes would rise vertically from the fire main, and in size would be suited to the number of hose connections that they supplied. They would be arranged, if possible, close to the main bulkheads, so as to supply hydrant valves on each side of the bulkheads. This would reduce the amount of piping and avoid as much as possible horizontal pipes outside of the passage. No other pumps except the two main fire pumps would connect to the fire main, and these pumps would draw water only from the sea.

In each pump compartment there would be installed a flushing or sanitary pump with a capacity of 350 gallons per minute. This pump would take water from the same sea stool or chest as the fire pump and deliver into the flushing main, which would extend the whole length of the central passage. This would be 5 ins. in diameter. The flushing pipe would be arranged with a loaded valve and by-pass to maintain a constant pressure of 50 lbs. per sq. in., and thus provide a constant service to all parts of the ship, dispensing with all tanks. The pumps would be designed especially for this service and so as to run very easy at full capacity.

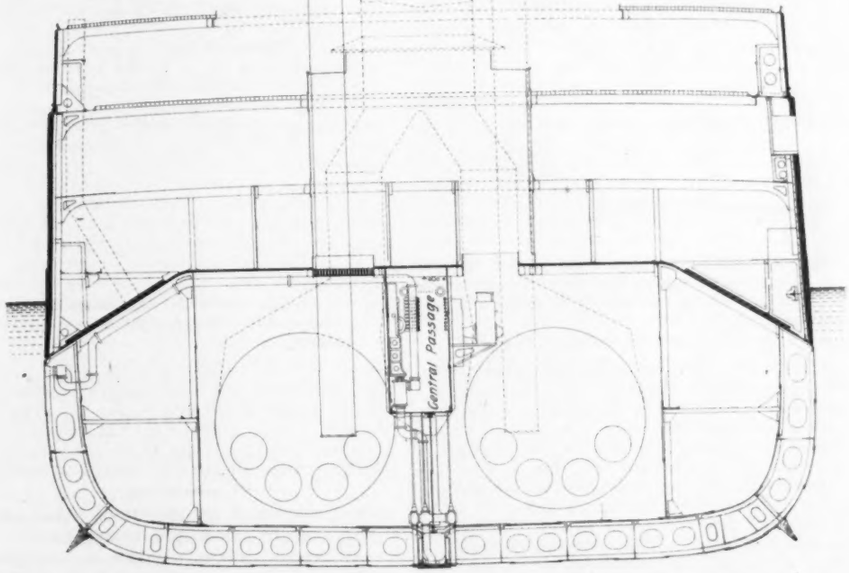
All connections to bath-rooms, water-closets, etc., would be made through vertical pipes from the main in the passage. All water-closets would be of the low back, house type, but with all fittings to suit a salt water service. Circulating water for the distillers would be taken from the flushing main and discharged overboard or returned to the main at a less pressure, if desired. Magazines above the water line would also be flooded from the flushing main. Magazines below the water line would be flooded by special arrangements as they are now. By this arrangement all plumbing and sanitary work would be arranged just as it is for a city water-works system, except that the water would be salt instead of fresh. In the branches leading up to such bath-rooms as should have hot water, arrangements would be provided in the central passage for heating the water as required from the heater system, a coil being used for that purpose so as to avoid any loss of fresh water from the boilers. The party ordering the water from central passage would give the temperature required. Hot water would be arranged for officers' baths and sick bay only. The engine room water service would also be taken from the flushing main by a branch direct from the pump discharge before it enters the central passage.

In each pumping compartment there would be installed a fresh water pump of say 75 gallons capacity each. These would take water from the fresh water tanks and deliver into a fresh water main pipe in the central passage, extending as far as the vertical distributing pipes require. A pressure of say 40 lbs. per sq. in. would be maintained at the pump constantly by a carefully adjusted relief valve and by-pass combined with an automatic steam regulator. There would be distributing pipes to the kitchen, the ice-making plant, the scuttle butts, the pantries and to such bath-rooms, including wash rooms, as fresh water is allowed to. On each distributing pipe in the central passage there would be a water meter and a record kept of the amount of fresh water used at each point where fresh water is delivered. All piping for this system would be of galvanized iron.

In each pump compartment there would be installed two boiler feed pumps, each capable of delivering to the main feed pipes at an easy speed of 450 gallons per minute, which would enable one feed pump in each compartment to supply the necessary amount of feed water at full power, leaving a complete spare set of feed pumps at full capacity. These pumps should be long stroke, moderately slow running pumps, very substantially built.

By the arrangement of pumping I have just described there would be in the engineering department, and installed in the port and starboard pump rooms, ten pumps, consisting of four feed pumps, two fire pumps, two low service salt water pumps, and two low service fresh water pumps. No other pumps are required and no others should be fitted.

ELECTRIC PLANT.—Electric light and power plant and questions affecting the generation and distribution of electricity, either for lighting or power purposes, have



CROSS-SECTION OF ARMORED CRUISER SHOWING PROPOSED CENTRAL PASSAGEWAY FOR SYSTEMATIZING INTERCOMMUNICATION AND PIPING ARRANGEMENT.

Designed by Geo. W. Dickie, General Manager Union Iron Works, San Francisco, Cal.

come to be very important on naval vessels. I believe, however, that in the latest designs for naval vessels the power of the generating plant is much in excess of the actual requirement. It is not conceivable that all the electrical appliances on board a naval vessel can be operated at the same time, or that all of them in operation at any time can be working at their full capacity. In the armored cruiser we are considering, it is possible that there might be required in time of action, provided everything that could be used at such time were in full operation and all working at their utmost capacity, power developed as follows:

If every electric light in the ship were turned on, 100 HP.; should all drainage pumps be working to their full capacity, 60 HP.; all ammunition hoists working at their full capacity, both turrets rotating at their highest speed and their ammunition hoists all working at the same time and with their carriages loaded and running up, 54 HP.; steering gear, putting the rudder head over, 25 HP.; ventilation, 60 HP. Now this is the utmost possible in time of action, and under circumstances entirely improbable, yet the aggregate is but 384 HP., and I have provided four units of 100 KW. each, which will provide power to operate everything that can possibly be worked at the same time and have one unit idle.

Should the vessel be coaling the possible power required would be: For lighting, if all lights were on, 100 HP.; for seven winches, all hoisting at the same time 175 HP.; ventilation, 60 HP. There might be 10 HP. on drainage, making a total of 345 HP., somewhat less than the possible power in action. I cannot conceive of any condition that could possibly require more than three 100 KW. units in operation, and accepting that as equal to the highest point under any condition, an installation of four such units is an ample provision for electric power. This installation would be provided in two independent dynamo rooms, located on each side of the central passage, between engine and boiler compartments, directly over the pump rooms already described. This location has many advantages of the usual position forward of the boiler compartment. In recent installations, independent condensers and air and circulating pumps have been installed in the dynamo rooms. This arrangement involves very long discharge pipes between the air pump at the dynamo room condenser and the feed tanks in the main engine room. In a case I am now engaged on the distance is 102 ft. This, I think, will be sure to give trouble. Located as I propose, the dynamo engines will exhaust directly into the auxiliary condensers in the pump room below. This also very much reduces the amount of auxiliary steam and exhaust piping. Each dynamo room would have a ventilating shaft, extending directly up to the weather deck. Fresh air would be taken from the central passage at the floor line and below the working platform. The air inlets, one at the forward and one at the after end of each dynamo room, would be fitted with watertight valves under control of the ventilation man in the central passage. The fresh air would be liberated at the proper points at the floor line so as to force the heated air up the ventilating shaft. There would be a switchboard in each dynamo room located against the wall of the central passage. All light and power circuits would be carried along the central passage and distributed by vertical conduits to all parts of the vessel where required. One-third of the electric power is applied direct in the central passage. The conduits will be carried along the sides of the passage and all branches will either go through the sides or the roof, through water-tight stuffing boxes. The object, as far as possible, would be to have all horizontal conduits in the central passage and the branch conduits from there supply light to a very limited area each, or power to one unit. This will greatly simplify the wiring and secure it as far as possible from damage in action; faults would be more readily located and repairs much more easily effected.

I asked an officer the other day, who had had considerable experience as executive on the largest warships, to mention some of the unnecessary things now fitted on these vessels that would be better left out. He replied that he could prepare such a list, but it would be such a lengthy one that I would be more surprised than instructed when I got it. I have tried in this attempt to find simpler methods for reaching the desired result on warships, to omit nothing that really needs to be done. The methods I propose have received much thought during the past ten years. All matters that I have connected with the central passage idea I have worked out in detail and know that they can be successfully incorporated into the design of these ships without in any way detracting from the fighting qualities of the ship or curtailing in any way the space needed for engines, boilers, magazines, etc., under the protective deck.

DESIGNS FOR BASCULE BRIDGES WITHOUT TAIL PITS.

The somewhat extensive use of the bascule type of drawbridge during the past few years, especially in Chicago, has led to the development of various designs for such structures. One of the latest of these has the special feature of requiring no tail pit, thus eliminating a costly and troublesome appurtenance. This design was invented by Mr. J. B. Strauss, C. E., Chicago Opera House Block, Chicago, and Roemheld & Gallery, Chamber of Commerce Building, Chicago, are the licensees. While no bridge of this type has yet been built, complete plans have been prepared for competitive bids for bridges over the Chicago River and elsewhere, and it will be of interest to describe the special features of the design. The Wabash Ry. has adopted the Strauss design for a drawbridge over the Cuyahoga River at Cleveland, O. This will be a through single-track single-leaf bridge of 150-ft. span between bearings, and will be worked by an operating strut.

The Strauss bridge is of the trunnion type, but differs from other designs in its arrangement of the counterweight, by which the use of cast-iron

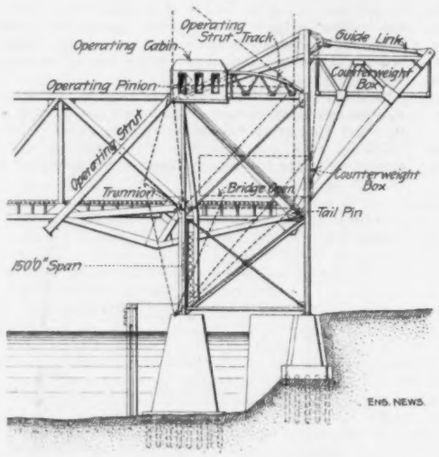


Fig. 1. Design for Through-Truss Railway Bascule Bridge, with Strauss System of Counterweight and No Tail Pit. (Wabash R. R. Bridge at Cleveland, O.)
J. B. Strauss, C. E., Chicago, Designer.

weights and watertight tail pits is dispensed with, thus reducing the first cost and maintenance expenses. The tail end of the bridge is made short enough to clear the water line, and at its extreme end are pins on which the counterweight is carried. In the overhead type, Fig. 1, a pair of trussed legs extends upward from the tail pins and support a transverse framework above the clearance line. This framework carries the counterweight box, which is filled with slag concrete. A pair of braced links, pin-connected to the fixed portion of the bridge, guides the box, the motion of which is downward and forward as the bascule leaf opens. The action is that of a parallel link mechanism, in which the main leaf trusses, the links, the fixed portion and the counterweight box are parallel and equal elements.

The box may be varied in shape and size. In the case of highway bridges it may be designed as an ornamental portal, working between reinforced-concrete towers and operating houses, harmonizing with the portals and combining to make an artistic structure. In its final position the counterweight is kept from 7 to 10 ft. above the roadway for highway bridges, and from 1 to 3 ft. for railway bridges. The arrangement for counterweights beneath the roadway is generally similar in design to the overhead type; the box then is flattened out to occupy the space under the fixed portion or approach, as shown in Fig. 2, which represents the design for a highway bridge over the Chicago River. The operation of the bridge is effected by means of an operating strut in railway bridges, Fig. 1, and by a tail-end rack in highway bridges, Fig. 2.

The main advantages claimed for the design are the economy due to the elimination of the tail pits (for any height of roadway above high water) and the substitution of concrete for cast iron in the counterweight. The concentration of the whole counterweight effect at the extremity of the tail end compensates for the shortening of the tail, and the pin attachment of the counterweight permits of great accuracy in balancing. It also permits the elimination of all curved structural work and track girders, which tends to greater economy in design, greater accuracy of shop work, and greater speed in construction and erection.

In the overhead counterweight the effect of the link stress is such as to reduce the load on the pivot pier, while with the counterweight underneath the approach truss the uplift is distributed so that from one-third to half of this is carried back to reduce the trunnion load, only the balance requiring anchorage. Lateral bracing of the main leaf is complete from end to end, and the machinery is applied at the points where the truss is most rigid.

The builders of this bridge state that in both the Wabash Ry. bridge at Cleveland, referred to

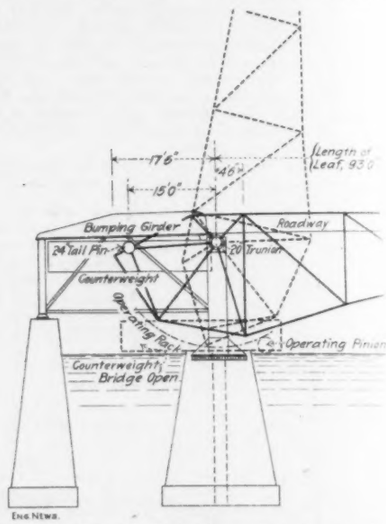


Fig. 2. Design for Deck-Truss Bascule Highway Bridge, with Counterweight Beneath the Approach.

above, and the Chicago & Alton bridge at Chicago, for which bids were recently received, the Strauss design proved its economy by having less material in both substructure and superstructure than was called for in any of the other designs of bascule bridges proposed by competing bidders.

ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The Society of Naval Architects and Marine Engineers held its twelfth annual meeting* in New York City on Thursday and Friday, Nov. 17 and 18, 1904. The four sessions of the meeting were held at the house of the American Society of Mechanical Engineers, 12 West 31st St. A dinner at Delmonico's, 44th St. and Fifth Ave., on Friday evening, closed the meeting. With the exception of this dinner, the time of the meeting was devoted wholly to the presentation and discussion of professional papers and the transaction of business. Eighteen professional papers were presented, all but three, which were presented by title only, being actually read in full or in abstract. The papers and the discussion are briefly reviewed below.

The report of the secretary, Naval Constructor William J. Baxter, showed a slight falling off in the membership, which was, however, made up by new members elected at the present meeting. The total membership now is close to 900. The financial report for the year indicates that the society is in very sound condition. Receipts and expenditures for 1904 are about $11,000 and $10,000, respectively. The present assets of the society amount to about $21,000, of which about $12,000 is in ready money.

The presidential address, of former Rear-Admiral Francis T. Bowles, was confined to a few words. Regarding the "General Slocum" disaster he said that it involves very serious legislative and administrative problems, and that very deliberate action is necessary to determine and put into practice the teachings of this accident. Re-

*The society meets but once a year.

ferring to the state of the shipbuilding industry in America, he said that while it was now perhaps worse than ever before, yet it had been shown that war-vessels can be built as cheaply here as abroad, and that the same was very likely true of merchant vessels. Yet there is now only one merchant vessel building, on either ocean; the lake shipyards, however, are full. "To build up a merchant marine owned and operated by American citizens," he said, "requires *some* present aid from Congress."

It was voted that all the past year's officers be reelected. These officers are: President, Mr. F. T. Bowles; Vice-Presidents, Rear Admirals W. L. Capps, R. D. Evans, C. W. Rae, P. Hichborn, and G. W. Melville, and Messrs. C. H. Cramp, F. L. Fernald, C. H. Loring, G. W. Quintard, E. A. Stevens, Stevenson Taylor and F. E. Kirby; Secretary and Treasurer, Mr. William J. Baxter.

A CALL FOR SIMPLER WARSHIPS.

It is fairly well known that battleships, and all kinds of war-vessels down to torpedo-boats, are tremendously complicated organisms. The concentration in a small space of great destructive powers, an entire regiment of engineers and fighting men, and a complete equipment of machinery for performing or expediting the service of the vessel; further, the necessity of securing, by proper arrangement and heavy armor, a protection corresponding in degree to the destructive power of the vessel; these considerations, in a floating structure which must be proof against deep-sea storms and must carry its own coal supply, inevitably tend toward excessive complexity. It seems natural to believe that this complexity would first press on the men who have to operate the vessel and on the designers, but that the contractor, who has only to build to plans and draw his pay, would be the last to worry over it. Yet the first technical paper of the present meeting was a vigorous protest, by a contractor for warships, against the excessive complexity of such vessels; the discussion of the paper was in part a rebuttal of this protest by designers. The ground for this appears to be that war-vessel specifications are so drawn as to throw a considerable burden of risk upon the contractor. His bid is based on incomplete designs, and competition causes him to take long chances on what may be subsequently added to the plans. The result is, in many cases, large loss to the contractor.

Under the title "Simpler Methods in Warship Design a Necessity," Mr. George W. Dickie, of the Union Iron Works, San Francisco, Cal., suggested means by which simplification of warships is attainable. His suggestions are in the matter of arrangement, without sacrifice of functions performed; that is, he accepts the *requirements* placed upon a battleship and merely seeks to meet them in a better manner than has been done heretofore. His introductory remarks, however, imply that the real trouble is with the requirements imposed:

> The modern warships, and I think also the men who design and build them, may be classed as complicated combinations of compromises that have come to be so involved in structure and function as to be quite incomprehensible even to the experts themselves, whose desire to leave nothing out that could possibly be brought into the design obliges them ever after to be inventing reasons why such devices ever found a place in the design of a warship.

The central features of Mr. Dickie's suggestions are: (1) Provision of a single main drainage channel, formed in the double-bottom between the two vertical keels. Pumps are placed at a central point, near the engine-room, to drain this sump, thereby eliminating a large amount of the pumping machinery and steam and water piping now used. (2) Provision of a central passage the full length of the ship, in which all piping and wiring is conveyed, which serves as main ventilation duct, and which also contains the telephone switchboard, pump and heater valves and some other items of central control. In conjunction with these two main features the author also suggested new methods of boat-handling and of coaling. The paper is abstracted at length on another page of this issue.

Mr. D. W. Taylor (Naval Constructor, Washington, D. C.) criticized both drainage-channel and central passage as being not practical devices. A warship having a sump constructed as Mr. Dickie recommends, would have its entire drainage system disabled if the ship grazed a sunken reef with its keel. The present system is safe against derangement by such a slight accident. Yet Mr. Taylor believes the idea of simplifying drainage is worth keeping in mind; simplification can be accomplished by merely leaving out about two-thirds the present amount of drainage equipment, though a drainage scheme after Mr. Dickie's line of thought, if worked out *complete*, would be worth considering. In the matter of ventilation and the central passage, Mr. Taylor holds that the present system of ventilation, by individual electric fans with separate inlets, is simple and more manageable. The central passage itself is so located as to be a danger to the vessel; if wrecked by a shot, or filled with poisonous gases from a shell exploded in the main air inlet, or filled with steam from a broken steam-pipe, the many vital functions concentrated in this passage would be paralyzed and the ship disabled. Since air is distributed from the passage to all the ship, a shell exploding, as noted, would stupefy or kill (by poisoning) two-thirds the people on board. Concerning telephone service on warships, Mr. Taylor stated that the problem is not yet solved. Of one installation it is reported that it "at times works perfectly, but at other times is absolutely unintelligible." Telephones on warships are badly needed, and a successful system will come sooner or later, but it is not yet here. The coaling scheme of Mr. Dickie was condemned by Mr. Taylor as utterly useless. The outboard (elevating) appliance, with its short reach, is awkward but might be made to work; the inboard (distributing) arrangement, however, is impossible, as it requires trimming coal in the bunkers for 60 to 70 ft. horizontally. The coaling problem has been of much difficulty, and has caused much complaint in the Navy, mainly on the score of excessively irksome trimming. The latest and best system involves running coal in bags down one or two chutes to the berth-deck, there distributing the bags along the deck to a large number of chutes and dumping directly into the bunkers down these chutes. This minimizes the work of trimming in bunkers.

Capt. William Hovgaard (Boston, Mass.) also criticized the central passage as dangerous. Such a passage is used in some navies, but Mr. Dickie wants to extend it to near the ends, which exposes it seriously to derangement by torpedoes, ramming, etc. The idea of a drainage system in the double-bottom is not new, either; it was formerly much used and is still used in the French navy exclusively. The French plan is to suspend a main drainage-pipe under the inner bottom, providing a pumping plant at each end, which is safer than the author's scheme. Mr. Dickie's claim that drainage pumps should not be made to serve as feed and fire pumps is, however, quite justified.

The question whether electric power for windlass driving is practicable raised some discussion between Mr. J. R. Andrews (Bath, Me.) and Mr. J. W. Kellogg (Schenectady, N. Y.). The former held that electric driving has the disadvantage of not limiting the pull on the chain, so that the latter is liable to be broken. Mr. Kellogg claimed, however, that this may be adjusted by using a high-resistance circuit to limit the current, or by using a separate generator-engine of proper size to stall under maximum pull; he stated that the General Electric Co. is ready at any time to take up the windlass question with confidence in being able to meet all requirements.

A FLOATING FORT FOR COAST-DEFENCE.

Mr. A. P. Stokes, of New York, N. Y., in a paper entitled "The Semi-Globular Naval Battery," submitted a design for a floating battery equipped with 15-in. guns and 21-in. armor. His idea is that by sacrificing speed, leaving only a bare remnant of propulsive power, and putting the weight and space into guns and armor, a valuable type of vessel is produced, valuable for supplanting coast-defense forts and for protecting wider reaches of water (large straits or bays, for example) than coast forts can cover. A secondary idea of his is to make the 15-in. guns fixed, and to train them in azimuth by rotating the ship and in elevation by changing trim. He therefore uses a circular ground plan, from which he develops a semi-globular vessel. The design is ingeniously worked out, but the value of such a vessel did not find appreciation in the meeting. However, Col. E. A. Stevens (Hoboken, N. J.) spoke in favor of the floating-fort idea; he believes that when a vessel once drops materially below the speed of the maximum fighting-unit, the battleship—as does our present monitor-class—then the fighting value is not decreased by dropping the speed down to a mere remnant. Mr. Wm. Hovgaard reported that the scheme of floating forts was discussed thirty years ago for the protection of Copenhagen harbor; it resulted in the building of fixed forts, one of these being constructed on an artificial island, yet at less cost than floating forts. Some of the objections to floating forts are: their cost, their ultimate vulnerability by mines or torpedoes, their awkward handling, docking, etc.; and in Mr. Stokes' design, the difficulty of training guns fixed to the vessel.

THE SEA-GOING BATTLESHIP.

Under the above title, Mr. Wm. Hovgaard presented a novel analysis of the fighting elements required in a battleship. Basing mainly on the superiority of the ordinary rifled gun over the torpedo, which results from the former's vastly greater frequency of hits (substantiated recently by the experiences in the Japanese war), the author develops the elements of a ship equipped with a main battery of 12-in. guns—the best naval arms yet produced. The general result is not unlike the latest American battleships, of the "Connecticut" class, though the armor he calls for is heavier, and some minor changes are introduced. The assumptions made, and the general course of the argument, are of great interest from a naval standpoint, but do not contain enough of general engineering value to warrant more detailed note here.

Former Chief-of-Engineers Geo. W. Melville expressed his approval of the paper, and remarked especially in favor of the triple-screw system which the paper advocates as preferable; Mr. Melville has stood in favor of this system for years past. Former Chief-Constructor F. T. Bowles (Quincy, Mass.) expressed approval of Mr. Hovgaard's position against using a second (upper) armored deck. This second deck was dropped from American naval practice some years ago, though retained in Great Britain; the fact gives the United States Navy a corresponding advantage over the British Navy.

AN EXPERIMENTAL INVESTIGATION OF PROPELLERS.

A paper of exceptional value, indeed a classic contribution to the science of marine engineering, was read by Mr. D. W. Taylor (Naval Constructor, Washington, D. C.), under the title "Some Recent Experiments at the U. S. Model Basin." It recounts the results of a very comprehensive set of experiments on three-bladed propellers, experiments made with all the refinement and practical purpose which the experience of the Basin makes possible. Thirty-two propellers were tested, all 16 ins. in diameter, but of varying pitch and varying width of blade. Thrust, slip, power, and speed were measured for each propeller in many repeated runs, and the results were finally summarized in curve-sheets. Without further reference to the paper at this moment, we may note that it is by far the largest contribution to experimental knowledge of propellers ever made. Col. E. A. Stevens remarked that the first experiments, those of Froude, were made on propellers of varied pitch only, while the later ones of Prof. Durand were on propellers of varied width of blade; Mr. Taylor tested propellers varied in both these directions, and used much larger propellers, hence secured more valuable results than the others. The paper describes, in appendices, a machine built at the Washington Navy Yard for planing the backs of the propeller-blades, and the dynamometer apparatus used to measure the thrust and the transmitted power. An abstract of this paper will be presented in our next issue.

Commander Wm. Hovgaard concluded from the curves of the paper that steam-turbines will have some difficulty in working their way into ship propulsion. Either the power must be subdivided among a number of shafts, to reduce the diameter of each screw, or the speed of the turbines must

be reduced to a lower limit than is now usual. This is due to the fact that the efficiency of propellers is low with low pitch-ratios. Col. E. A. Stevens confirmed one of the author's observations, that under certain circumstances a narrower blade gives higher power, by an observation in practice, which seemed to indicate greater losses with the wider blade. Mr. J. A. Linnard described the appearance of a propeller in Mr. Taylor's tests when exhibiting "cavitation." The propeller tips were only 4 ins. under the surface, yet there was no surface disturbance, but only a milky space which, with increasing speed, extended from the back face of the propeller rearward in a cylindrical volume.

On the question of full-size propeller experiments, which had been suggested, Mr. Taylor said that very great difficulties would be involved in such tests, but that it might yet be possible to solve them sufficiently well to get comparative results. He also inclines to the belief that modification of the back of the propeller-blade may suffice to solve the high-speed difficulty.

THE SEAWORTHINESS OF TORPEDO VESSELS.

"Some Further Notes on the Performance of the Torpedo Vessels of the United States Navy at Sea" were presented by Lieut. L. H. Chandler, who was in command of the destroyer flotilla which made a trip to Cavite, P. I., early this year. The paper gives a log of the run in some detail, and presents certain conclusions as to the performance of the vessels. The destroyer flotilla, of five vessels, made the run of 14,492 sea miles from Norfolk, Va., to Cavite, P. I., in 125 days, of which 61 days were spent in port. The average speed when under way was 11.3 knots. The worst weather experienced was between Malta and Port Said, on which run, also, a severe sandstorm was encountered, 150 miles from the African coast. The vessels are 250 ft. long and have a displacement of about 420 tons. Some of the observations and conclusions are:

The period of roll is 4.5 to 5.0 seconds, and the amplitude of roll is sometimes over 35°. The bilge-keels seem to prevent cumulative rolling. With a head sea, or sea forward of the beam, the rolling is more uneasy than with it from any other direction. When running too fast into a head sea, heavy pounding of the bow, racing of the screws, and a pounding of the flat stern into passing seas, all combine to make the conditions almost unbearable, and this state of affairs strains the hull structure very greatly. A ratio of length to beam of 10.6 is too great for that kind of work. Rolling and pitching never caused any serious trouble with the machinery, though the engines required careful handling when racing. In a following sea the boats yaw badly and are very difficult to steer accurately.

To enable the boats to buck a head sea better, I would like to reduce the ratio of length to beam, even at expense of a couple of knots smooth-water speed.

I would like to have coamings on all important hatches about four feet high, and have the fire-room blower cowls raised the same amount, to keep loose water about the decks from finding its way below so freely. Hatches could then be kept open much longer than is now the case.

I would like to have some modification or strengthening of the stern which would decrease the pounding and consequent shattering tendency to the hull.

Messrs. Hovgaard and Wetherbee discussed the paper briefly. The excellent performance of the vessels, in spite of their being heavily overloaded, was noted with approval.

THE ARMORED CRUISER "COLORADO."

This vessel was described in a paper by Asst. Naval Constructor J. M. Powell. It is the most fully protected of any armored cruiser in the world. It has recently passed its preliminary trials. The vessel is the first of the U. S. Navy to be fitted with the new Navy standard pressure of 125 volts, and moreover has the most complete electric plant of any American war vessel. The ship is 502 ft. long and 69 ft. 6½ ins. broad on L. W. L., and has a trial draft of 24 ft. 1 in.; its trial displacement is 13,785 tons.

The electric plant comprises three 100-KW. sets and four 50-KW. sets, distributed in two dynamo rooms. Most of the wiring is in enameled iron conduit. The consumption is as follows:

Incandescent lamps	1,275 equiv. 16 c. p. lamps.
Arc lights	14 3½-ampere arcs.
Search-lights	6 30-in. projectors.
Motors	142 of 0.75 to 210 HP.

Total motor capacity, 845 HP. rated. Of this, 113 HP. is in ventilating-motors. The installation of five motors driving air compressors is contemplated. This would bring the total motor rating up to 1,030 HP.

In comparison herewith it should be noted that the main engines are designed for 23,000 I. HP., to give a speed of 22 knots.

Specifications for testing the electric plant, a pitching diagram, curves of power and speed taken from the preliminary trial trip, and a gun and armor diagram of the vessel are appended to the paper. The trial curves also show the E. HP. curve deduced from the model tests. Comparing these with the I. HP. at trial, the efficiency of propulsion proves to be about 0.55.

THE MILLER MARINE COALING CABLEWAY.

Mr. Spencer Miller (New York, N. Y.) described the most recent experiences with his well-known cableway for coaling at sea in a paper entitled "Coaling Warships at Sea—Recent Developments." The evolution of this cableway is here outlined, and the trials of the device in the British, Russian, and American navies are described in detail. It may be remarked that the Baltic Squadron is fitted with this coaling device. The cableway has been developed so perfectly that its weakest point at present is the sea-anchor used for holding the carrying-rope taut, a feature whose improvement involves no great difficulties.

STEAM-YACHT RACING ALLOWANCES.

Mr. Geo. W. Melville, ex-Engineer-in-Chief of the United States Navy, presented an interesting paper on "Time Allowance for Steam-Yacht Races." This problem had been placed before him by the Regatta Committee of the New York Yacht Club, who wished to arrange for certain steam-yacht races. Mr. Melville develops his rule in detail in his paper, giving at all points his reasons and his assumptions. A maintained purpose in the calculation was to discriminate as nearly as possible against "freak" designs. The analysis is much too long and complex for further note here. Most of it deals with the resistances to the ship's motion; on the score of power, the grate-surface is taken as a measure and the boat taxed accordingly. Forced draft is also taxed, quite materially, and in any case is limited to 2 ins. of water.

Mr. H. De B. Parsons (New York) reported that the only race yet sailed under these rules, in fact the race for which they were originally prepared, showed a time-difference between the two yachts (the "Haouli" and the "Kanawha") on a run of 60 sea miles, of almost exactly the amount which calculation by Mr. Melville's formulas gives as the difference of time-allowances for these two yachts. Mr. Parsons supported the principle of discriminating against "freak" designs, by asserting that, like many other sports, steam yacht racing tends toward the dangerous, and proper rules should oppose this tendency. Yet Mr. Parsons does not believe that forced draft should be limited to 2 ins., as 4 ins. is permitted on torpedo-boats and, moreover, "a steam-yacht owner might be willing to burn up his boilers for the sake of winning a race, and should not be debarred from doing so." This is in some contrast to the principle of safety, noted above. Mr. Parsons pointed out that the grate-surface measurement, which is a more representative measurement than heating-surface, does not provide for oil-fuel. On the other hand, indicated power, or mean effective pressure, which might prove satisfactory for reciprocating engines, would not answer for steam turbines. Of the other discussion, which dealt more with the general subject of racing rules, we need note only the suggestion that classing closely as to length is very important, in order to keep at about the same speed for the same length of boat, thereby eliminating the question of humps in the resistance-curve which otherwise is of considerable influence.

THE CENTER OF LATERAL RESISTANCE.

In a brief paper entitled "The Position of the Center of Lateral Resistance," Mr. L. E. Bertin emphasized the fact that the center of lateral resistance does not coincide with the geometrical center of longitudinal under-water section, nor with the center of gravity of the vessel, and that its position is of considerable importance in determining whether a vessel will tilt inward or outward in turning, and how much. An experiment to determine the center of lateral resistance in the case of a sailing-vessel, by towing a model laterally and finding the point of application which produced no lateral tilt, was cited.

Mr. A. A. Packard (Providence, R. I.) mentioned that the question of center of lateral resistance becomes very important in the case of high-speed "power-boats," where the rudder must be placed so as to minimize tilting when the boat is turned at high speed. In the case of some torpedo-boats built by Yarrow the rudder was placed very deep, for this reason. Mr. Wm. Hovgaard threw further light on this same point. About 20 years ago a small torpedo-boat of the Danish Navy capsized when turning sharply at high speed in a heavy sea. The vessel had small initial stability, but while turning its centrifugal force was counterbalanced by the rudder pressure; when the rudder was suddenly returned, however, this balance was disturbed and the boat was thrown over, sinking immediately. Mr. M. Main pointed out that the bow-wave, set of sails, etc., all affect the position of center of lateral resistance, so that model-towing would be of little service in case of a sailing vessel.

A paper on "Maintenance of Machinery in Merchant Ships," by Mr. R. Haig, provoked some discussion regarding condenser tubes and steam-pumps. Mr. C. H. Wheeler claimed that it is not practicable to cast the valve-decks of pumps as part of the pump cylinders, but that proper construction avoids any trouble from valve-seats working loose. The condenser-tube question is always a bad one. In harbors especially is the water active in corroding these tubes. A large lightering service in New York harbor was stated to have wholly abandoned surface condensers, for the reason that the water destroyed the tubes so rapidly. Trouble with tube-packing is minimized, according to Mr. Wheeler, by using condensers in which only one end of the tube is packed. We which only one end of the tube is packed. A full abstract of Mr. Haig's paper appears on another page of this issue.

GASOLINE LAUNCHES.

Two papers on high-speed gasoline launches, such vessels as are sometimes called "autoboats" or "power-boats," brought out quite animated discussion. Mr. Clinton H. Crane presented a paper on "High-Speed Gasoline Launches," and Mr. A. A. Packard a paper on "Speed and Power of Recent Motor Boats of Several Types."

Mr. Crane introduced his paper thus:

The application of internal combustion engines to the propulsion of launches is by no means a novelty, but great public attention has of late been attracted to the subject, owing to the high speeds attained by a certain number of small launches driven by engines of this type.

The older makes of motors weighed from 80 to 200 lbs. per B. HP., and in sizes up to 75 HP. have proved extremely satisfactory in all sorts of working vessels. Engines of this type have run satisfactorily day in and day out with practically no attention or trouble.

The manufacturers of automobiles have been the first to realize the possibilities of a light-weight motor, and have been able to reduce the weight to between 8 and 20 lbs. per B. HP. in the best practice of to-day. To have divided the weight per unit of power by ten is certainly a remarkable achievement. The reduction of weight has been accomplished in three ways: (1) The elimination of unnecessary material; (2) the employment of higher grade material; (3) the use of higher piston speeds. The higher piston speed has necessitated modifications of design in four particulars, mechanical balance, ignition, lubrication and cooling. All four of these difficulties have been met with entire success in the engines used by automobiles.

The author then described, as a specimen of the new type of boat, a recent launch designed by him, the "Vingt-et-un II." This boat has reached a speed of 22 knots in public trial. It is very steady in rough water and steers remarkably well. The boat has been put through progressive speed trials. Its principal dimensions are:

Length, L. W. L.	38 ft. 9 ins.
Beam	4 ft. 7 ins.
Mean draft	11 ins.
Total wetted surface on trial	146.3 sq. ft.
Displacement on trial	3,850 lbs.
Engine, Smith & Mabley, 4-cyl. Simplex:	
Cylinders, diam.	6½ ins.
Stroke	6¾ ins.
Speed at full speed	850 r. p. m.
Piston speed	956 ft. per min.
B. HP. at full speed	68
Weight, in racing condition, with fuel for 50 miles	51 lbs. per B. HP

Some outline drawings of the boat, trial curves and photographic views, are appended to the paper.

The paper of Mr. Packard presented a series of views of a number of recent gasoline launches and tables and diagrams giving their dimensions and speed performances. These boats are all under 50 ft. in length. In discussion, Prof. H. C

...er remarked that the piston-speeds of the ...ches described are not at all excessive, when ...pared with torpedo-boat practice; the speed ...ht possibly be increased well beyond present ...its, perhaps to 1,400 ft. per minute. The feat... of coincidence of bow and stern wave sys...s, which Mr. Packard had shown to have had ...marked effect on the resistance of the vessel, ...bably is not of any moment when the waves ...e so long in proportion to the boat as they are in ...ese vessels; that is, wave-length several times ...long as the boat. Col. E. A. Stevens, cal...lating from the resistance-curve given by Mr. ...ane, concluded that the increase of skin-fric...n was much lower than it should have been, in ...e case of the "Vingt-et-un II." This would in...icate that the boat rises bodily out of the water. Mr. Crane confirmed the conclusion; at high speed the water just around the boat sinks on an aver...ge 4 to 5 ins. with respect to the boat, although the latter is doubtlessly lower with reference to the general water-surface than it is when at rest. Mr. Packard noted that Mr. Crane's design proves a wide stern to be unnecessary to prevent change of trim at high speed, and praised the design as being better in rough water than any corresponding boat in existence, besides showing extreme speed and excellent steering qualities. The subject was further discussed by Messrs. H. F. Donaldson, C. P. Wetherbee, D. H. Cox and W. P. Stephens. It was suggested that the Navy Department should aid in developing boats of the kind in question by experiments in the Model Basin.

SHIPPING AND SHIP-BUILDING ON PUGET SOUND.

A long paper on this subject, by Mr. F. W. Hibbs, was presented by title only, but because of the interesting facts presented we abstract a small part of the paper here:

In 1903 there were 326 vessels, of 139,301 gross tons, registered from the state of Washington. In the same year there were only 178 vessels, of 376,969 gross tons, registered from New York state, while all other states are far below these figures. Considering all classes of American vessels, registered, enrolled and licensed, Washington stands second in number and third in tonnage among American states, New York being first in both cases.

As the shipping of Puget Sound represents practically all the shipping of the state of Washington, these statistics are interesting as giving an idea of the relative magnitude of the shipping of this great inland sea, possessing a magnificent gateway from the ocean, 15 miles wide without a bar, a series of deep waterways with an unbroken shore line of 1,800 miles, extending 80 miles from east to west and an equal distance north to south, with splendid harbors easily approached and well protected by surrounding hills, forming one of the most attractive prospects in the Western Continent.

Puget Sound is also the only port of entry in the United States where the greater portion of the tonnage entering and clearing in the foreign trade is of American registry. For the year ending June 30, 1903, the figures are:

	Entered.		Cleared.	
	American.	Foreign	American.	Foreign.
Sail	62,227	208,463	125,866	125,111
Steam	665,308	244,770	707,459	253,303
	1,180,768			1,211,739
Total, tons				2,392,507

The figures for 1894 and 1903 show the growth of the trade of Puget Sound in ten years:

	Exports.	Imports.	Total.
1894	$4,942,040	$1,230,399	$6,172,439
1903	32,490,823	12,177,243	44,677,066

Lumber is the principal item of trade.

. . . . . .

The timber used for shipbuilding is variously known as Douglas Fir, Yellow Fir and Oregon Pine, although practically the same in its general characteristics. The wonderful growth of the trees, with girths of over 30 ft., reaching a height in some instances of 300 ft., half of which is without a limb and of comparatively slight taper, the perfectly straight and true grain of the wood, its close fiber, toughness, strength and elasticity, practically equal to white oak and superior to the yellow pine of the southern states, combined with a lighter weight than either, the readiness with which it is obtained and the ease of working it, altogether offer unequalled possibilities in the way of timbers for shipbuilding purposes. The strength of this material is shown by the results of an extensive series of tests made under the direction of the U. S. Navy Department about two years ago, a summary of which is as follows:

PROPERTIES OF DOUGLAS FIR.

	lbs. per sq. in.
Tensile strength	13,000
Tensile strength across grain.....	350
Tensile strength for bending.....	10,000
Elastic limit for bending.....	6,000
Modulus of Elast. for bending.....	1,500,000
Strength for compression across grain without destructive deformation	1,200
Modulus of Elast. for compression cross grain	4,000
Crushing strength for compression end on to gain	9,000
Modulus of Elast., end grain compression...	70,000
Modulus of Elast., Torsion.....	27,000
Shearing strength, with grain.....	15,000
Crushing strength for long columns.....	6,000
	lbs. per cu. ft.
Weight per cubic foot.....	35

Several other papers were presented at the meeting, some being read while others were presented by title. The following were read, but without material discussion:

"Uniform Specifications," by Mr. W. D. Forbes (Hoboken, N. J.). This paper makes a double argument, first for uniform specifications for materials, second for the "bonded guarantee" system of buying, the latter being especially recommended to the government. As Mr. Stevenson Taylor observed, however, contractors for government work would hardly look upon this system with favor, as it is hard enough to get pay for work done, without having money tied up indefinitely in guarantee bonds.

"Subdivision of Weights in Ships' Displacement," by Mr. N. Soliani. The author complains that practice differs greatly in the manner of classifying the various items of a ship's structure and equipment, so that classifications of different origin can not be compared directly. He suggests a basis of classification in some detail, enumerating the items to be classed under Hull, those under Armor, etc.

"On the Rules of Lloyd's Register for Building Yachts to Class," by Mr. George Stanbury. This paper gives a statement of how the rules of Lloyd's Register specify that yachts shall be measured, in determining the proper sizes of material to use. Steel and wooden yachts have separate rules.

Two papers that were read by title only (besides the one of Mr. Hibbs' previously noted) are: "Recent Launching Practice of the Atlantic Coast," by Asst. Naval Constructor R. H. M. Robinson; and "Recent Launching Practice of the Pacific Coast," by Mr. E. P. Lesley. These papers describe the general launching methods and give friction curves, lubrication data, etc., applying to recent launchings of naval vessels.

VISION OF RAILWAY ENGINEMEN AND FIREMEN IN RELATION TO SIGNALING.*

By Dr. Nelson M. Black.†

To protect, space and control the trains of a railway system, various methods of signaling are used, and the visual requirements of employees actively engaged in operating trains, or giving and taking signals, is a matter of no small importance. This system of controlling trains requires, in the daytime, the determination of the position of a semaphore arm, about 4 ft. long by 6 ins. wide, or distinguishing the color of a disk about 17 ins. in diameter, displayed on a pole about 26 ft. high. At night the color of a 6-in. lens, lighted by a kerosene lamp, must be observed. This must be determined by the enginemen at sufficient distance in which to control their trains. Mr. R. Quayle, Superintendent of Motive Power of the Chicago & Northwestern Ry., furnishes the following data, which are the result of some recent experiments in controlling fast trains:

With the ordinary brake, 70 lbs. train-line pressure, a six-car train running 70 miles an hour can be stopped inside of 2,000 ft., approximately 1,900 ft.; and when the high-speed brake, 110 lbs. train-line pressure, is used on the same train and running at the same speed, the train can be stopped in 1,450 ft.

It will be seen that a signal must be read at not much less than half a mile (2,640 ft.), as a few seconds are necessary for the engineman to shut off his steam and apply his air, and in each one of these seconds a train, traveling 70 miles an hour, is covering 88 ft.‡ There is no question that next to the necessary practical knowledge of his engine, the vision and color perception of the engineman is of the most importance.

Conditions existing about an engine, such as the escape of steam when an injector is used, when the whistle is blown, from leaking valves or connections, from the poorly packed piston rods of air pumps, cylinders and steam chests, will often completely envelop the engine and cab. Steam and soot from the smoke-stack is often blown back against the cab windows, covering them with steam and dirt and making it next to impossible to see through them, to say nothing of obtaining a view of anything through the condensed steam and smoke. This is especially true in passing under the viaducts or bridges entering the railway yards of large cities, where there are many moving engines and trains, and signals must be closely watched for. In freezing weather the escaping steam is especially bad, as the windows are coated with ice, and vision through them is out of the question. The escape of steam inside the cab in cold weather often coats the side windows with frost and ice, but rarely the front ones, as the rush of cold air against them while in motion keeps them clear. Double glass is also used, with an air space between, which prevents their freezing. The dust raised by passing trains often coats the windows, especially if they are damp from escaping steam; the engineman's position, being on the right side, escapes most of this, however, on roads which run their trains right-handed on double tracks. The cloud raised from ploughing through snow-drifts shuts off all vision for the time. Some considerable complaint is made of the drivers throwing mud and dirt on the front windows in moist weather.

The glare from the furnace door when the engine is stoked makes the reading of signals much more difficult. There is an iron shield above the furnace door on the engineman's side, which protects him somewhat. Many enginemen have their seat curtained off to relieve them of this glare. After looking into this glow from the position of a fireman during the time required to shovel in five or six shovels of coal, it is an utter impossibility for a novice to read a signal. Firemen have told me they could not even see the steam gage for several minutes after a stoking, and when one takes into consideration that from three to ten tons of coal are handled in a two to five hours' run, there is not much let up from looking into the fire-box, and when this is done daily for five or six years, or even longer, before a fireman can expect to become an engineman, it must be a good pair of eyes that can stand it and pass the required standard examination for promotion, without a rest or change.

The divergent rays from the headlight make it more difficult to read signals if there is fog, snow or mist in the air; with the electric headlights, while they are of the greatest advantage in all other ways, this is much more aggravated; an immense disk of reflecting and refracting particles is directly before one, and it is almost impossible to distinguish signals through it. If these headlights were built on the same principle as the searchlights of the Navy, so that they would throw parallel rays and could be deflected to strike the track at, say, 100 yards' distance in front of the engine, they would be greatly improved. This effect was obtained for Dr. Young and myself on the C., B. & Q. Ry. by Mr. J. A. Carney, Master Mechanic of the Burlington Division, by making an extension to cut off the divergent rays and stopping the light down with a diaphragm. An 18-in. extension with the light stopped down to a pencil about 9 ins. in diameter made a perfect light. It is impossible to estimate distances accurately behind an electric headlight.

The constant supervision of an engine takes no small part of an engineman's time and attention, and his duties are far more than sitting on the seat and watching for signals. This is especially true when there is any trouble with the various mechanisms under his care.

Lenses of various colors were experimented with in looking into the firebox from the fireman's position, and then trying to read day and night signals. The night signals were harder to see because of the glare being more intense in the surrounding darkness, the daylight relieving part of its intensity. Smoky lenses of the deeper shades allowed one to look into the fire-box without producing a scotoma before the eyes, but distinguishing signals with them and seeing the various mechanism about the cab distinctly, is out of the question; the color signals are made very indistinct. Green lenses are very good, but they blot out the red lights entirely, making one blind to red. Red lenses make the green appear dirty white, producing green blindness. Blue lenses do not cut out enough of the bright rays, and one is troubled with scotoma. A light amber lens, such as referred to in the German abstracts in the Annals of Ophthalmology and by Dr. H. H. Seabrook, as having been tried in the German army for target practice, give a perfect result. I could look into the fire-box of the large type engines, see all parts distinctly, relieved of the blinding glare, see about the cab perfectly, climb on the seat with no spot before my eyes, and the signal lights maintain their clear definition of color, white being tinged a slight yellowish. The green light can not be seen at so great a distance as with the naked eye, but red and white can be seen an equal distance and with equal distinctness.

A number of firemen have volunteered the information that they had passed their entrance examination all right,

*Abstract of a paper read at the November meeting of the Western Railway Club, Chicago.

†Milwaukee, Wis.

‡The writer overlooks the function of the distant signal, which is designed to notify the engine-runner of fast trains in what position the home signal stands, and far enough in advance to give him time to stop his train, if necessary, before passing the home signal.—Ed.

but when they were re-examined after four or five years' service their left eye was not so good as the right, which is the one next to the fire-box in stoking.

Protection of some kind is the only method of overcoming the effect produced by the impact of snow, mist, rain and wind against the eye, and all sorts of devices are resorted to. Fully 90% of the men questioned admitted they carried some form of protection glass for such an emergency. With lenses before my eyes I found no difficulty in facing the worst storms; the glasses did not become dimmed enough to prevent sufficient vision to read signals at any distance they could be made out with prevailing weather conditions, and the condition of the eyes was infinitely better. The larger the lenses the more perfect the protection. The question of fogging is one small factor against the use of glasses by trainmen, as the engineman is unable to see distinctly about his cab for the few moments his glasses are fogged, after contact with cold, but he is equally unable to see for the same length of time as a result of coming in contact with snow, rain and wind with the naked eye. The lenses also protect the eyes from the flying coal dust in the cab. The reflection from snow, from a body of water, the sun near the horizon, and the shimmer on hot days, was best overcome with the amber lenses.

A very great deal depends, in night signaling, on the care taken of the lamps used, and the lenses in the spectacle frame of the semaphore arm must be kept clean. A lamp not properly trimmed or turned too high will smoke its lenses, and as a consequence the signal is dim or almost invisible. Under such conditions enginemen with defective color perception or a tendency toward color confusion can not distinguish between red, green or white; even with normal color perception the signal can not be seen at sufficient distance to control a train. The difference in the care taken of the lamps is very marked in going over 40 or 50 miles of road.

Comparative tests were made of different makes of roundels used in signal work. It was found that the difference in intensity of color of a signal was due in a great many cases not to the care taken of the lamp, etc., but to the poor quality of the roundels themselves, there being a difference of 77% in the amount of the original illumination transmitted by the poorest and best; spectroscopically, the difference between 17.4% and 73.1% of pure red light transmitted by the red roundels, and 13.2% and 30.2% of pure green light by the green roundels. Track tests showed the poorest red just visible at 8,599 ft., and the best not lost at 15,688 ft.; the poorest green lost at 6,487 ft., and the best at 12,370 ft.

The result of my observations has been, in brief:

1. The best-known standard of visual acuity and color perception should be required of men concerned in the active operation of trains.

2. The signal systems now in vogue, while they are not perfect, are sufficiently adequate for the standard of vision required and the present speed of trains.

3. Certain physical and accidental conditions about engines interfering with vision can not be overcome unless the position of the enginemen can be changed.

4. Certain atmospheric conditions interfering with vision can not be overcome; others can be mitigated or entirely relieved by the use of some form of protection to the eyes.

5. Glasses are not a hindrance to enginemen, and their use should be allowed when required to protect the eyes or to bring the vision up to required standard, but no person should be accepted into service requiring them.

6. With four reports emanating from four different sources of equal merit and standing, and all different in small details, the obtaining of perfect uniformity in examination of railway employes is out of the question, as it can not be expected that the officials of different roads will all decide on the same report.

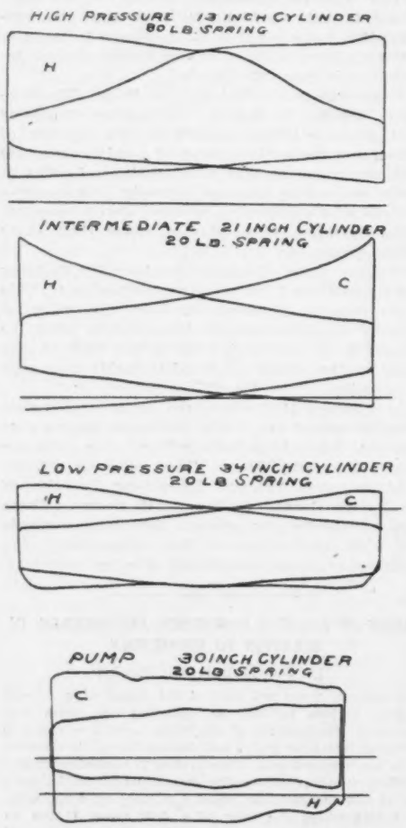
7. Furthermore, state legislation on the subject of vision and color perception of railway employees is being seriously considered. Two states, Massachusetts and Ohio, have statutes regulating this. As nearly all railroads pass through a number of states, it would be well for the societies from which these reports emanate to agree in all details, as the state laws will necessarily be based on them; and if different states have different standards, an engineman qualifying in one and not in another, with his run extending in both, would be in serious difficulty. The Ohio law is as follows, and the Massachusetts law is practically the same:

9,816. Sec. 1. Be it enacted by the general assent of the State of Ohio that no railroad company shall hereafter contract to employ any person in a position which requires him to distinguish form or color signals, unless such person within two years next preceding has been examined for color blindness in the distinct colors in actual use by such railroad company, and by a competent person employed and paid by the railroad company, and has received a certificate that he is not disqualified for such position by color blindness in the colors used by a railroad company. Every railroad company shall require such employee to be re-examined at least once within every two years at the expense of the railroad company, provided that nothing in this section shall prevent any railroad company from continuing in its employment any employee having defective sight in all cases where such defective sight can be fully remedied by the use of glasses or by other means satisfactory to the person making such examinations. (As amended March 3, 1888.)

HIGH DUTY FROM A DIRECT-ACTING PUMPING ENGINE WITHOUT FLYWHEEL OR HIGH-DUTY ATTACHMENT.

A duty record of over 102 million foot-pounds was attained by a direct-acting, triple-expansion Worthington pumping engine at the Millburn pumping station of the Brooklyn Water-Works in a contract trial held in July last. The trial was conducted by Messrs. R. C. Carpenter, R. P. Bolton and F. J. Oakes.

The pumping engines installed at Millburn are of the standard low-duty, triple-expansion tandem type, manufactured by Henry R. Worthington. Semi-rotary steam valves are used and the high-pressure cylinder alone is provided with a cut-off. All cylinder heads and barrels and the reheaters are jacketed with steam under boiler pressure. Each cylinder is accessible, all heads can be taken off and the interior of each cylinder exposed without interfering with the plunger rods on the other cylinders. The pumps are run condensing, a Worthington surface condenser being used. A closed feed-water heater between the low-pressure cylinder and the condenser heats water for the entire plant, five times as much feed water as is required for the pumps themselves. A temperature within 15° of that of the exhaust pipe is maintained in the heater. There are reheaters between the high-pressure cylinders and also between the intermediate pressure cylinders and the low-pressure cylinders.



Indicator Cards from Worthington Triple-Expansion Pumping Engine.

All water used in the boiler plant, including that for the other engines in the station, was passed through the heater of the Worthington engine on test, resulting in a saving of coal for the whole plant of 4%. If the Worthington engine had been credited with all heat returned by it to the boilers, its duty would have been much greater.

The engine cylinders are 13, 21 and 34 ins. diameter, and the water plungers are 30 ins. diameter, while the stroke is 25 ins. Engine No. 1880 was tested on July 21-22, and engine No. 1881 was tested on July 18-19. The test run was for 24 hours in each case. The following table summarizes the results obtained in the test:

Engine No.	1880.	
Heat Supply.		
Steam pressure at boiler (lbs.).	125.3	
Steam pressure at engine (lbs.).	121.5	
Calorimeter (lower thermometer), Deg. F.	283.4	
Calorimeter, back pressure (lbs.)	1.07	
Moisture in steam (%)	1.21	
Measured condensation from engine cylinders (lbs.)	74,979.00	72,7
Measured condensation from jackets and reheaters (lbs.)	12,924.	12,6
Total moisture in steam (lbs.).	1,063.6	8
Heat in total steam to engine and moisture (B. T. U.)	103,613,992	100,021,
Heat Returned by Engine.		
Jacket and reheater condensation returned to boiler (B. T. U.)	4,184,848	3,87
In feed water (B. T. U.)	6,673,231	6,47
Total heat credited to engine (B. T. U.)	10,858,079	10,347,
Actual net heat used by the engine (B. T. U.)	92,755,913	89,673,9
Plunger area (sq. in.)	706.860	707.8
Net plunger area (sq. in.)	703.326	704.2
Total single strokes	189,548	191,1
Average length of strokes (in.).	24.745	24.5
Piston speed (ft. per minute)	135,716	135,8
Net displacement per 24 hours (gals.) "E"	14,280,761	14,318,8
Ascertained slip (gals.)	123,895	51,4
Percentage of plunger displacement remaining "F"	99.132	99.64
Capacity under contract conditions ("E" × .97) (gals.)	13,852,338	13,880,3
Capacity (actual pumpage) (gals.)	14,156,876	14,267,4
Suction lift (ft.)	17,034	16,3
Delivery head (ft.)	63,659	62,7
Total head pumped against (ft.)	80,693	79,1
Total pounds water lifted (plunger displacement)	119,101,548	119,419,4
Total foot-pounds work done (plunger displacement)	9,610,661,244	9,450,374,4
Duty.		
Duty per 1,000,000 B. T. U. on plunger displacement (ft.-lbs.) "G"	103,612,384	105,385,9
Duty per 1,000,000 B. T. U. (contract conditions) ("G" × .97 (ft.-lbs.)	100,504,012	102,224,3
Duty per 1,000,000 B. T. U. (on actual pumpage) ("G" × "F") (ft.-lbs.)	102,713,028	105,006,5
Duty per 1,000 lbs. dry steam plunger displacement	110,671,000	112,632,0

THE LANGLEY FLYING-MACHINE EXPERIMENTS are referred to in the latest annual report of the U. S. Board of Ordnance and Fortifications, which explains the connection of this Board with the experiments. The passage in the report which refers to the experiments is as follows, according to the New York "Tribune":

Early in the year 1898 a board composed of officers of the army and navy was appointed to examine the models and principles of the aerodrome devised by Dr. S. P. Langley, secretary of the Smithsonian Institution, and to report whether or not, in its opinion, a large machine of this design could be built, and, if so, whether it would be of practical value. The report of this board was referred to the Board of Ordnance and Fortifications for action, and Dr. Langley was invited to appear before the board and further explain the proposed construction.

In view of the great utility of such a device, if a practical success, the board, on Nov. 9, 1898, made an allotment of $25,000 for the construction, development and test of an aerodrome to be made under the direction of Dr. Langley, with the understanding that an additional allotment of the same amount would be made later. On Dec. 18, 1899, the additional allotment of $25,000 was made. The construction of the machine was delayed by Dr. Langley's inability to procure a suitable motor, which he was finally obliged to design. The aerodrome was completed about July 15, 1903, and preparations for its test were made at a point in the Potomac River, about forty miles below Washington. Preliminary arrangements having been completed and tests made of a quarter-size model, the first attempt at actual flight with the man-carrying aerodrome was made on Oct. 7, 1903.

On this occasion there were present on behalf of the board Major M. M. Macomb, artillery corps, and G. H. Powell, clerk of the board. Major Macomb, in his report to the board, stated that "the trial was unsuccessful because the front guy post caught in its support on the launching car, and was not released in time to give free flight, as was intended, but, on the contrary, caused the front of the machine to be dragged downward, bending the guy post and making the machine plunge into the water about 50 yds. in front of the house-boat."

This accident made necessary the removal of the house-boat to Washington for the more convenient repair of damages. The repairs having been completed, on Dec. 8, 1903, another attempt at a trial was made, this time at the junction of the Anacostia and Potomac rivers. Gen. W. F. Randolph and Major Macomb, members of the board, and Mr. Powell were present. Major Macomb reported as follows: "The launching car was released at 4.45 p. m. . . . The car was set in motion and the propellers revolved rapidly, the engine working perfectly, but there was something wrong with the launching. The rear guy post seemed to drag, bringing the rudder down on the launching ways, and a crashing, rending sound, followed by the collapse of the rear wings, showed that the machine had been wrecked in the launching—just how it was impossible for me to see."

March 3, 1904, the board stated that it was not "prepared to make an additional allotment at this time for continuing the work," whereupon Dr. Langley requested that arrangements be made for a distribution of the aerodrome material procured jointly from the funds allotted by the board and by the Smithsonian Institution. Dr. Langley was informed that all of the material would be left in his possession and available for any future work that he might be able to carry on in connection with the problem of mechanical flight.

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The first contracts for the New York barge canal are advertised in this week's issue of Engineering News and the bids are to be opened about the middle of December. The six sections advertised include some very heavy work and great interest will be felt in the result of the bidding. According to a published account, the estimates made for these sections by the Board of Advisory Engineers are less by about $120,000 than the estimates made by the State Engineer's Department in connection with the Barge Canal survey in 1901. The estimates made at the time of these surveys amounted to $5,891,000 for the six sections and this has now been cut down to $5,771,000.

It remains to be seen whether contractors will come forward with bids which will support this reduced estimate. There will be, no doubt, active competition for the contracts, but responsible firms will not fail to take into account the risks which are connected with the work. For example, the work is to continue for a considerable number of years, in the process of which very radical changes may take place in the prices of materials, in the cost of labor and in the conditions under which labor can be operated. On the other hand, the state is a paymaster of unquestioned solvency and the work is of such magnitude and is to continue for so long a time that labor-saving machinery can in many cases be profitably installed.

When work first began on the preparation of these contracts for public letting, it was the announced purpose of Gov. Odell to make the prices on these contracts a test as to whether the entire work could be completed inside the estimated cost of $101,000,000, on which the people voted. At the present time, unless the bids should be enormously excessive, there seems no prospect that the whole question as to whether or not the canal shall be built will be reopened. Nevertheless the advocates of the canal as well as its opponents will watch with great interest to see what the bids indicate as to the probable cost of the whole enterprise.

The important position occupied by the cantilever girder in modern bridge design is perhaps a reasonable excuse for making public the following inquiry, and the somewhat extended answer which seemed necessary to satisfy it.

Sir: Who was the first designer in the United States of steel cantilever bridges? Also, was the United States the pioneer in this style of construction, and what was the first cantilever railway bridge constructed? J. N. H.
Chicago, Ill., Oct. 31, 1904.

The genesis of the cantilever is prehistoric, and cantilever bridges have been built in wood by both savage and civilized peoples since very ancient times. Modern scientific development of cantilever bridges dates back to about the middle of the nineteenth century. To answer our correspondent's questions in order, it appears quite certain that the first American designer of an iron cantilever bridge was Prof. W. P. Trowbridge of the School of Mines of Columbia College, New York City, and afterwards Professor of Engineering at Yale College. In an article published in Engineering News of Dec. 29, 1883, Prof. Trowbridge is attested to have designed in 1867-8 a cantilever bridge of two spans, one 725 ft. long and the other 600 ft. long, to cross the East River at Blackwell's Island, opposite 76th St., in Manhattan. About two years later, Prof Trowbridge originated another design for a bridge at the same place in which the cantilever arms of the original design were shortened and the space between them filled with a suspended span 180 ft. long. Two other designs, both based on those of Prof. Trowbridge, were afterward submitted to the New York & Long Island Bridge Co., which had been organized on the showing made by the design of Trowbridge to build the bridge named. It is hardly necessary to say that none of the proposed bridges was ever constructed.

The first iron cantilever bridge to be constructed in America was the Kentucky viaduct of the Cincinnati Southern R. R., built in 1876-7 by Mr. Shaler Smith of the Baltimore Bridge Co. This structure was designed originally as a continuous bridge computed in the assumption of fixed points of contraflexure. The late Mr. L. F. G. Bouscaren, M. Am., Soc. C. E., then Chief Engineer of the Cincinnati Southern Ry., refused, however, to approve this method of calculation, and as a result the design was modified so as to render the points of contraflexure fixed by cutting the lower chords. The chief reason for adopting the cantilever design was because of the possibilities it afforded of erecting the girders without the use of falseworks. It was the successful erection of this bridge, followed in 1883 by the work of Mr. C. C. Schneider in designing and erecting the Niagara Cantilever Bridge without falseworks that first directed the attention of the whole engineering world to what is now considered the greatest merit of the cantilever girder, namely, the fact that it can be erected in long spans without the use of falseworks.

While America is doubtless entitled to the claim of having proved to the world the important fact just stated, she cannot lay claim to having originated the design of cantilever girders in the development of iron bridge building. Mr. George C. Mehrtens, in "A Hundred Years of German Bridge Building," shows that the German engineer Gerber designed and built a cantilever road bridge with a span of 124 ft. over the River Main at Hassfurt in the year 1867. The idea of the hinged continuous girder is considerably older, however, than Gerber's design just mentioned. According to an article in London "Engineering" of Feb. 28, 1890, Stephenson, in 1846, and Mr. Edwin Clark in 1850 premised the severing of continuous girders at the points of contraflexure and of suspending the central portions from the "semi-beams or cantilevers." In 1850 Sir John Fowler actually constructed a wooden model to demonstrate the possibility of doing exactly what had been premised by Stephenson and Clark. An account of the experiments made with this model will be found in the Proceedings of the Institution of Civil Engineers, Vol. IX., p. 256. Reference to the same principle of construction was made by Mr. Baldwin Latham in 1858, Mr. W. H. Barlow in 1859 and Professor Ritter, of Hanover, in 1862. Professor Ritter, in order to prove his contentions, worked out in detail the strains in all the members of a 525-ft. cantilever span. In 1864 Sir John Fowler and Mr. Benjamin Baker designed a steel cantilever bridge of 1,000-ft. span for the proposed South Wales & Great Western Direct Railway Severn Crossing. This span was afterwards reduced to 600 ft., full plans prepared and contracts for construction let when financial difficulties stopped further work. This work was followed in 1867 by a series of articles by Mr Baker on "Long Span Bridges," in which the author discussed particularly the economical advantages of hinged continuous girders. In 1871 Messrs. Fowler and Baker were again associated in the design of a bridge across the Severn consisting of two 800-ft. cantilever spans, and two years later in 1873 Mr. Baker designed the superstructure of a proposed ferry bridge across the Tees, which included a 650-ft. cantilever span.

The first cantilever railway bridge constructed appears to have been a 148-ft. span completed over the Warthe at Posen in 1876. London "Engineering" of Feb. 28, 1890, publishes a sketch elevation of this structure, which appears to antedate slightly the Kentucky Viaduct completed in 1877 by Shaler Smith. The next cantilever railway bridge of importance to be constructed was that for the Michigan Central R. R. crossing of the Niagara River, completed in 1883. Previous to the completion of the Niagara cantilever, however, work had been begun on the great Forth Bridge in Scotland; the final design for the Forth Bridge was approved in 1881 and contracts for construction were awarded in 1882.

A very good idea of the remarkable growth of electric interurban railways in the Middle West is given by a map of the electric railway lines in Illinois, issued by the Arnold Electric Power Station Co. of Chicago. The map shows electric railways projected as well as those under construction, and it is evident that if all the projects were to reach realization, the northern portion of the state particularly would be thoroughly gridironed. The lines actually constructed, however, are nearly all in the vicinity of the larger cities, serving to connect them with smaller cities located five to twenty miles distant. When all the projected lines are completed, it will be possible to go by electric railway from St. Louis to Chicago; but of the total distance of 300 miles, not more than 85 miles is actually completed, and only at one point is any new construction in progress.

That these lines are designed for passenger traffic and not for freight traffic, is evident from the way in which they are restricted to the regions of dense population and the vicinity of large towns. Very few projects are found in the southern section of the state where the population is chiefly rural, and the lines in the vicinity of Chicago form a third to half of the whole mileage actually constructed.

SPECIFICATIONS FOR A SEWERAGE SYSTEM.

Specifications for a "complete sewerage system" are at hand. For inability to recognize that the second party to a contract has rights of any kind, the author of these specifications is almost in a class by himself. Yet, as most of his numerous errors are such as are found from time to time in similar specifications, it seems well to quote a few clauses.

The very first clause is an index to the character of the whole specification. It reads substantially as follows:

> The work under these specifications consists in furnishing all labor and materials required to build a complete sewerage system for the city of ——, *or such portion of it as may be decided upon by the Engineer.* (Italics ours.)

This is practically equivalent to asking contractors to bid on a quantity sheet with the quantities omitted. It scarcely seems credible that an engineer should not have enough business knowledge to know that there is usually a great difference, between the actual cost of building a few hundred feet of sewers and of building many thousand

feet. Surely one who has ever himself asked for quotations on sewer pipe or brick, in varying quantities, must have learned that manufacturers' discounts vary greatly with the size of the order. Perhaps it may be worth a moment's time to ask why a manufacturer can afford to sell a large quantity of pipe or brick at a lower unit price than he can afford to sell a small quantity.

To answer this question it is necessary roughly to analyze the cost of producing and marketing such products. The more important cost items are included in the following enumeration:

1. Excavating raw materials.
2. Transporting raw materials.
3. Grinding, mixing and shaping.
4. Burning in kilns.
5. Handling and storing finished product.
6. Loading on cars or boats.
7. Superintendence and office expenses.
8. Sales agents' commissions and salaries.
9. Interest and depreciation of plant and clay property.
10. Taxes.

The "fixed expenses," which are included largely in items 7 to 10, inclusive, form a far greater part of the unit cost of the clay products than is commonly supposed, and this part of the unit cost increases as the size of the plant decreases, or as the annual output decreases. Where the manufacturer can be sure of one or more orders that will work his plant to its full capacity, he can obviously make a decided discount in his unit prices, and still be sure of a maximum annual profit. These elementary facts are certainly well enough known, but not well enough considered by those who write such specifications as the one under discussion.

Aside from the fact that the contractor's prices are largely governed by the prices quoted to him by manufacturers, the contractor himself is a manufacturer and applies the same reasoning in fixing his prices for the sewer system that he proposes to construct.

If, for any reason, there is a probability that funds will not be available for the completion of such a work as this sewer system, then the work should be divided into two or more sections, upon which separate and combined bids may be asked. The contractor will then have something definite to bid upon instead of a sliding scale of quantities which, at the engineer's discretion, may be anywhere between 0 and 100% of the work listed in the bidding sheet.

To add, if possible, to the uncertainty of the problem before the contractor, the author of the specifications under discussion adds a clause reading about as follows:

> The dimensions and location of all parts of the work shall be in accordance with the specifications, drawings and plans. The plans referred to are not necessarily those submitted before letting the contract. Detailed plans will, in many cases, be prepared and carefully adjusted to the features of the ground or conditions, and the plans above referred to shall include these subsequent plans.

Why not ask the contractor to swap his work for some money "unsight and unseen?" It is frequently said that a contractor who is financially ruined under certain specifications must have "run up against a very honest engineer" whom he had hoped to hoodwink. It is too true that this is often the case, but who knows how much oftener financial failures are due to bidding upon just such specifications as these? Certainly the gambling factor in contracting exists largely by virtue of the one-sidedness and the indefiniteness characteristic of so many specifications.

Passing from these general clauses to the so-called specific clauses, we find such as the following:

> Where required, drainage shall be effected by a drain pipe laid below the sewer, all at the expense of the contractor.

"Where required" by whom or by what? By the engineer, or by the exigencies of the case? It may be safely inferred that the engineer has the power, under the clause, to direct the building of as many feet of subdrain as he may see fit—and all without agreeing to pay for a foot of it directly. Indirectly, however, he may pay for subdrains under the whole system in the form of higher unit prices—although in fact not a single foot of subdrain may be built. A clause like this indicates, as do nearly all the others, that the engineer had made no study of subsurface conditions before he drew his specifications. Instead he has apparently delegated this part of his work to every contractor who chooses to bid intelligently. Unfortunately, this criticism applies not to one expectionally bad specification, but to scores of specifications, which indicate that the standard practice in this country is to make only surface surveys, leaving subsurface surveys to be made by the trench-digging laborers after the contract has been awarded.

We need not wonder that sewer work is seldom bid upon except by a few local contractors who are more familiar with local subsurface conditions than is the engineer; for profiles of soils and rocks to be encountered are seldom shown in engineers' drawings, and an outside contractor will usually have neither time nor inclination to make such a profile for himself. Nor should it be a cause for wonder that local contractors often bid exceedingly high on some work, and on other work find that their prices are ruinously low. These conditions will continue to exist until careful surveys and estimates are made the basis of carefully drawn specifications.

SEWER VENTILATION BY FANS AND BY NATURAL MEANS.

The ventilation of sewers is a far more troublesome question in Great Britain than in America. The subject comes repeatedly before the various British associations of municipal engineers and sanitarians, and is rarely even mentioned by similar organizations in America. Nor is the contrast between the two countries merely one of words. Special ventilating chimneys and less pretentious shafts are provided on many British sewerage systems, but are almost unknown in this country.

Among the possible explanations of these differences, are the following: (1) As a rule, our sewers are of more recent construction than the British, and both because of better construction and a shorter time for getting out of order, are less likely to become foul through pockets and deposits; (2) our sewer grades are perhaps better, as is indicated by the fact that we rarely pump sewage here, whereas pumping in England is common; (3) a larger percentage of our sewerage systems are on the separate plan, consisting of pipe sewers with good alinement as well as grade and with self-cleaning velocities; (4) water consumption in America is much higher per capita than in Great Britain; (5) we have no disconnecting chambers in our house sewers or drains; (6) the omission of the S-trap at the foot of soil pipes is becoming more and more extensive here, and where omitted the street sewers are ventilated through the extension of each soil pipe to and above the roof; (7) regardless of any and all these factors, the use of manholes with perforated covers is common with us.

The foregoing reflections have been prompted by the forced or fan systems of sewer ventilation at Leicester and Darley Abbey, England, described elsewhere in this issue. Although we question the wisdom of spending money for such a purpose in Great Britain, and feel confident that it would be unwise here (of course there might be rare exceptions in both countries), we nevertheless give considerable space to the subject because of its possible interest to many of our readers and because of the careful and extended tests made at Leicester by Mr. E. George Mawbey, M. Inst. C. E. That gentleman appears to be fully convinced that sewer ventilation is necessary and that it may be effected at a reasonable price by means of fans, on extractor shaft and numerous special air inlets. It may be added that at Leicester disconnecting chambers are not used.

The first questions that occur to us regarding the advisability of adopting fan ventilation of sewers, except in rare cases, relate to (1) the sanitary need and value of further ventilation than can be secured by natural means, and (2) the efficiency and cost of forced ventilation when applied to a whole sewerage system. As already intimated, sewer ventilation does not appear to be a troublesome question in America. In England there are plenty of people who believe that perforated manhole covers and ventilating shafts run up the sides of houses, or in some instances larger and independent shafts, afford all the ventilation needed. But there are also many who deem such a system of ventilation unreliable, insufficient and even a menace to health. From an examination of municipal reports and society papers bearing on the subject, we conclude that both theory and practice in Great Britain is strongly on the side of the efficiency of natural ventilation, and that most of those who think and act in accordance with the opposite conclusion misconceive and exaggerate the evils of imperfectly ventilated sewers, and of sewer ventilation by natural means.

We do not deny that many sewers in England give out offensive odors from manholes and other openings to the street surface, and, of course, we believe that the emission of such odors should be stopped. But we think that as a rule they can be stopped without resorting to forced ventilation and that in any case they have no great effect upon the public health. Experience in both Great Britain and America seems to teach that perforated manhole covers and house ventilating shafts, combined with proper sewer cleaning and flushing, will prevent the accumulation of large or dangerous quantities of foul air in sewers.

It is undeniably true that the foul air removed by such a system of natural ventilation must escape either from the manholes at the street level or from the ventilating shafts at the house tops, but given a sufficiency of vents of each class, the volume of outflowing foul air at any one point will seldom be large and rarely if ever be dangerous. Momentarily unpleasant to pedestrians, it may be, and possibly in some narrow streets an occasional whiff may reach a window, but such occurrences are no more a cause for alarm than many other of the smells that reach the nostrils of the city dweller.

In the ideal city no such smells would exist, and in striving for the ideal we shall of course try to abolish foul air from sewers, but many and far graver evils must first be attacked at their source.

Granted for the moment that the natural ventilation of sewers is insufficient, would the additional results due to mechanical ventilation be a material gain, and could they be obtained at a reasonable cost? As general propositions, Mr. Mawbey answers these questions in the affirmative. His figures of cost indicate that a few hundred feet of sewer can be ventilated at a small per capita expense per year, for motive power, but they make no allowances for capital charges or attendance, nor for the additional cost due to long stretches of sewers on which there are few or no houses. It seems probable, also, that on the average run of sewers the leaks of air at joints and various openings would greatly increase the volume of air to be moved in order to effect the ventilation of the house drains, which appears to be one of the main objects of the forced ventilation system. With combined sewers, and especially those designed to carry the large volumes of rainfall for which we in America provide, the fans and the power to operate them would have to be very large. Any sewerage system, separate or combined, in Great Britain or America, would have to be cut up into sections by gates or other means and the number of such sections, together with their gates and fans, might be larger than has been anticipated.

Mr. Mawbey's tests for carbon dioxide show larger quantities in the ventilated sewers, as compared with both the outer air and the air from (other) unventilated sewers than might be expected. The samples designed to show the effect of ventilation were taken from manholes. It would have been interesting and might have been instructive to know the quantities of CO_2 in the ventilated house drains.

We cannot close our discussion without some words of condemnation of the disconnecting chambers so general in Great Britain, and of commendation for Mr. Mawbey and the Leicester authorities for dispensing with them. The object of those chambers is to cut off the street sewers from the house plumbing. This practice entails a useless expense, makes a miniature cesspool on each premises, retards the flow and may contribute to stoppages in the house drain and impair the natural ventilation of the sewerage system. Such chambers, we believe, are practically unknown in America, and are never de-

nded by our sanitary authorities. It is stated at they were introduced in England as a consequence of an illness of the Prince of Wales in 871, attributed, we presume, to the "sewer gas" which so much was formerly heard, and unfortunately is still heard at times on both sides e Atlantic. The sewer gas fetich has resulted in vast amount of misdirected sanitary effort, but r comparative backwardness, for many years, municipal sanitation, and the absence of a central administrative body in this country, has at ast saved us from being burdened with some seless sanitary or insanitary practices.

Reverting in conclusion to the fan system of wer ventilation, we wish to say that notwithstanding the doubts which we have expressed as to its necessity and value, the inventors (Messrs. Shone & Ault) are to be commended for the scientific manner in which they have attempted to meet the undoubted British demand for a thorough-going and perfectly controlled system of sewer ventilation, and Mr. Mawbey also deserves praise for his painstaking tests of a system which he looked upon with doubt at the outset, but also with the open mind of a searcher after the sanitary ideal.

LETTERS TO THE EDITOR.

Upward Wind Pressures.

Sir: The writer has noted with some interest the various letters in recent issues of Engineering News regarding wind pressures. It seems to him, however, that the wind pressure from the really destructive type of storm has received no consideration by any of your correspondents.

A storm of the rotary type reducing the atmospheric pressure suddenly on the exterior of a building or on bridges, causing an upward pressure on the floors, requires for the stability of the structure different treatment from that proposed in the average text-book. The writer has seen the leeward roof pulled out or rather blown out while the windward was left sticking up in the air. Stiff riveted construction throughout bottom chords, capable of taking compression as well as tension, is a method of construction more worthy of consideration than refinement in methods of computation. Frequently computation on the basis of such *upward* pressures will indicate that the pressures involved in surprising destruction of framed structures are merely nominal in amount instead of "exceedingly great" as too frequently is rashly assumed.

Yours truly,

C. A. P. Turner.

816 Phoenix Bldg., Minneapolis, Minn., Nov. 17, 1904.

(It might be suggested that estimates of upward pressures in cases of actually observed destruction would prove useful. Knowledge of pressures against vertical surfaces is much more definite. If facts are presented showing specific amounts of upward pressure deduced from this or that case, the recognition of this kind of pressure in design will be much forwarded.—Ed.)

Concerning the Merit System.

Sir: As a subscriber who believes heart and soul in the Civil Service System, pray grant me space to add a word to your admirable comment on a letter in your issue of Nov. 17 on "How Should Inspectors be Appointed?"

The Civil Service System, or as the writer prefers to call it, The MERIT SYSTEM, is a method of procedure which appeals to the best instincts of all right minded people. It is nothing new, though its application in the United States is barely a score of years old, and its establishment in New York city does not go back over a decade. Any system in its early stages of application is somewhat imperfect; yet even in the short time mentioned—while it has been, so to speak, in the building, while it was being adapted and developed to our conditions—it has worked great good by promoting faithfulness and efficiency and checking demagogism and jobbery.

It is a great pity that it was not given its true name, THE MERIT SYSTEM. This title would be a continual challenge to its detractors and opponents. He who attacks it arrays himself against merit, justice and fair play. The complaints of the detractors of merit always have a hollow sound. They do not ring true. They dare not go squarely at it. They cannot. In addition to this, the true title, MERIT SYSTEM, must necessarily have a moral effect and a stimulating action upon all that it touches.

Your correspondent asks how he could pass two examinations and fail in (a later) one. How, when he had reached 90% in two could he fail in another? The answer is not far to seek. The Civil Service System requires that he shall submit on examination evidence of proficiency. It rests with him to offer this evidence, and it is entirely conceivable that for any one of several reasons he may or may not submit adequate evidence at successive examinations. Indeed, it is entirely conceivable and possible that a desirable man may fail, if on examination he does not take care to submit in the answers to the questions the knowledge that he possesses. The system is trial by evidence. The evidence must be submitted according to rule. The race is an open one, but the winner must take the trouble to run and he must comply with the rules of the race. He who would have the prize must prove his claim by winning it.

It is not a question of practical men or mechanics or students or what not. It is a question of merit proved by written evidence submitted at a uniform test which is made to have as direct a bearing as possible on the duties of the position.

That one applicant takes the test seriously and studies either privately or at a school is rather to his credit than otherwise. In England, where the Civil Service System has existed longer and has developed further, the Civil Service School of Preparation is a recognized institution. And why not? The man who complains that an applicant is a student, or studies for an examination, by inference places himself in the class of those who made the word Reform necessary after the words Civil Service. Any one who holds that it is preposterous for an applicant to really study in order to hold a civil position is in need of watching if not of reforming.

If it was unfortunate that the Civil Service System was not called the Merit System; it was equally unfortunate that the word Reform should become so pronouncedly attached to the words Civil Service. So much buncombe has been perpetrated in the name of Reform that it is no longer in the minds of some a fit word to associate with that eminently respectable old word Merit. What we need is not so much Reformers, who may be in the business through "pure joy" of the performance or pure rascality—not Reformers, but Referees.

All merit asks is a Referee who will see fair play. A reformer who settles down and becomes a referee is useful. What the Civil Service System needs more than anything else is to be let alone. It is doing good work. It cannot attain its maximum efficiency in a day or a year. It does not need to be experimented with, it requires rather the guardianship of all true citizens, protection from its enemies and deliverance from its anxious friends. It is slowly working out its salvation and perhaps our political salvation also. Just in so far as it approaches and coincides with the merit system will it grow and prosper.

With thousands now enrolled under the banner of merit it bids fair to gradually open up *public service as a career* and to replace a political serfdom with an intelligent self-respecting body of public servants.

In a recent political campaign in New York city the town was placarded from end to end with the reputed remarks of Mr. Andrew Carnegie on the creditable condition of the public utilities, etc., under municipal control. "What Mr. Andrew Carnegie said," and "What Mr. Andrew Carnegie did not say," was bantered about as political capital. But a still voice whispered that the reason why things were looked after so well here and there was not because one or the other of the political parties was in or out, but rather because a Civil Service System had come into operation, which had succeeded in setting merit to work here and there, and had fought a good, true fight and had held it in its job.

D. H. R.

New York City, Nov. 17, 1904.

Formulas for Crown Thickness of Masonry Arches.

Sir: In your issue of Sept. 15, 1904, Mr. Emile Low presents a new formula for crown thickness of masonry arches which is compared by Prof. Cain in your issue of Oct. 20 with formulas of Trautwine, Rankine and others. In all of the formulas under discussion the crown thickness is made to vary as the span or as the square root of the span. But the thrust in an arch varies as the *square* of the span. It is difficult to conceive therefore how these formulas can give reliable results except for short spans in which defective joints require more consideration than stresses due to loading. It is to be noted that the formulas give widely divergent values for spans in excess of 50 or 60 ft.

Just what the limit of span would be for reliable values it would probably be best for the authors of the formulas to suggest. I am not prepared myself to advance any more reliable rule for stone arches, but wish only to call attention to the danger of placing too much reliance on the formulas in the case of long spans. In order to show this defect in Mr. Low's formula by reducing it to an absurdity, assume an arch of span 500 ft., rise 20 ft., and surcharge 2 ft. The resulting crown thickness is less than 9 ft. Yet for an arch of these dimensions the pressure on joints at crown would exceed 400 tons per sq. ft., or more than ten times the safe load. Admitting that this is not a practical case, it nevertheless shows that at some point the formula fails to apply, and the question is where is the limit for which it is reliable.

Very truly yours, Daniel B. Luten.

Indianapolis, Ind., Nov. 15, 1904.

(The application of the "reductio ad absurdum" to engineering formulas is such doubtful value, in our opinion, that to exhibit its effects we take the liberty of carrying Mr. Luten's calculation a step farther. Suppose the arch-ring were made 18 ft. deep instead of 9 ft. The dead-load on the arch, and hence the thrust, would be nearly doubled, especially if the arch be designed with hollow spandrels; meanwhile the joint surface would also be doubled. The joint-pressure per square foot would thus be left almost unaffected, even though the thickness of ring is doubled. The "reductio ad absurdum" therefore fails, because it does not show that there is a thickness of ring which will meet the assumed conditions. The example leaves us to infer that the assumed case is beyond the limits of feasibility for the type of construction in question, the masonry arch.

Certainly the fact that a formula will not apply outside of the field for which the construction itself is possible cannot be used as an argument against the formula. This seems to us a fatal defect in Mr. Luten's argument.

Most engineering formulas, it is admitted, even those which are claimed to be "rational," have a restricted range of applicability. Pile formulas are an oft-quoted example. Masonry-arch formulas are equally good illustrations. The stress-considerations should, theoretically, include both the moment and the thrust, but as a matter of fact the moment is in most practical cases by far the predominant factor. Therefore, formulas for masonry arches, quite generally understood to be intended for rough approximation only, base in some way on moment; or in the case of a formula that is quite broadly empirical, as the Low formula, the formula is based on designs which were themselves determined by the factor of moment. Any such formula, of course, will then involve an irrationality in disregarding joint-pressure, which lays it open to criticism by the "reductio ad absurdum."

We agree with Mr. Luten in thinking it proper that all engineering formulas, and especially those which are very broadly empirical, should be accompanied by a statement of their proper range of application. In the case of Mr. Low's formula, the table given with the formula in our issue of Sept. 15, 1904, meets the same requirement in part. If any of those interested in the subject will make a more definite statement of the fields of masonry-arch formulas, we shall be glad to give space to it.—Ed.)

DATA IN REGARD TO THE PRESENT LOW WATER PERIOD IN THE SOUTHEASTERN STATES.

By M. R. Hall.*

On account of the recent large increase in the amount of developed water power in the southeastern states, and the great number of plants now projected, or in course of erection, there is an unusual interest in the present extreme drouth and its effect on the flow of streams. As a result of these conditions, numerous requests for data regarding the flow of streams have recently been made to the United States Geological Survey by engineers and others.

In the accompanying table are stated briefly the rainfall conditions leading to the present low stage of streams, together with approximate discharge data for October, 1904, in such tabular form that it can be used in connection with the published data for 1903 and previous years. Similar data for October, 1903, the month of low water in that year, are placed alongside for convenient reference.

Detailed records of precipitation have not been prepared, but statistics may readily be obtained from the U. S. Weather Bureau for many stations in this section of the country. The excesses and deficiencies of rainfall for Atlanta, Ga., are stated as typical of conditions which have prevailed over the whole area.

The annual precipitation for Atlanta is about 50 ins. At the end of the year 1902 there was an accumulated deficiency of 6.42 ins. for the year. From Jan. 1 to June 30, 1903, there was an ac-

*District Hydrographer, United States Geological Survey, Atlanta, Ga.

Table Showing Maximum, Minimum and Mean Monthly Discharge of Southeastern Rivers for Months of Lowest Water in Years 1903 and 1904.

Stations.	Drainage area, sq. miles.	October discharge in cu. ft. per sec.	1903.	1904.
Broad River, Carlton, Ga.....	762	Max.	690	380
		Min.	575	305
		Mean	651	308
Tugalo River, Fort Madison, S. C.	593	Max.	928	520
		Min.	552	380
		Mean	634	430
Oconee River, Dublin, Ga	4,182	Max.	4,799	770
		Min.	1,580	570
		Mean	2,044	628
Chattahoochee River, Norcross, Ga.....	.....	Max.	1,330	580
		Min.	1,015	505
		Mean	1,103	544
Cahaba River, Centerville, Ala...	1,049	Max.	676	130
		Min.	184	90
		Mean	243	109
Tallapoosa River, Sturdevant, Ala...	2,500	Max.	2,620	510
		Min.	765	260
		Mean	939	314
Coosa River, Riverside, Ala.....	7,065	Max.	3,590	1,650
		Min.	2,620	1,220
		Mean	2,922	1,360
Tennessee River, Chattanooga, Tenn.	21,418	Max.	9,740	6,800
		Min.	7,100	5,000
		Mean	7,124	5,474
Ocoee River, McCay's, Tenn....	.....	Max.	767	235
		Min.	332	200
		Mean	365	211
Hiwassee River, Murphy, N. C.....	410	Max.	1,070	190
		Min.	235	150
		Mean	280	176
French Broad River, Newport, Tenn....	1,737	Max.	1,685	1,400
		Min.	735	410
		Mean	975	572
Nolichucky River, Greeneville, Tenn..	1,099	Max.	850	388
		Min.	350	340
		Mean	434	356

cumulated excess of 8.06 ins., which slightly more than compensated for the deficiency of the previous year. From July 1 to Dec. 31, 1903, there was a deficiency of 9.10 ins. Since Jan. 1, 1904, the deficiency has increased each month, except August, amounting to 18.75 ins. for the twelve months ending June 30, 1904, and to about 23.5 ins. for the 16 months ending Oct. 31, 1904.

As a result of the great deficiency in precipitation for the winter months of 1903-1904, the streams reached a very low stage in the early summer. The August rains temporarily relieved the situation slightly. At the beginning of September, surface conditions were scarcely normal, with a great deficiency in the deeper waters, while the almost total lack of rain for September and October (0.66-in. for the two months) has caused a long period of extremely low water. Conditions were but slightly better for the last half of September, and the improvement from Nov. 1 to present date (Nov. 12) caused by rains and cooler weather has not been great. The data given for the several stations when compared with the previous records may safely be used by engineers as a basis for estimating the present low water flow of other streams in these states.

TARRING MACADAM ROADS.*

The tarring of highways is no idle whim, but a method of maintaining them which should be placed in the foreground with other details of maintenance. As roadways are shaped and surfaced, they should be tarred. Much time will pass before this method is adopted, in spite of the certainty of acquired results. The object of banishing dust is praiseworthy enough in itself, but since we may do this while also solidifying and improving our highways, the system should be well received by all who are interested in our public routes. My method is not to hold down the dust for two days, a week, or a month—it is to prevent its formation. I do not comprehend how the separation of the fight against dust and the maintenance of the highways can be considered. That which forms the dust arises from the disintegration of the road. A road without dust is one that does not wear out, or at least does so imperceptibly.

First of all, let me prescribe a coal tar subjected to one distillation, that is to say, deprived of the light oils of the raw material. These oils are no less valuable for their effect in the road-tarring operation than they are in the industries. It is indispensable to employ undistilled pitch, which boils at about 80° C. This product should be brought to a temperature approaching that of ebullition, since in this condition it is most mobile, and penetrates best into the material of the roadway. To spread a pitch at 60° C. is a grave error; on the other hand, at 80° it is easily inflammable and spills over the side of the boiler. This inconvenience I have avoided by having a special apparatus made by Chappée & Co., of Mans, which permits of the watching and regulation of the heating. This device is light, and, being mounted on wheels, is easily transported. The pitch leaving this apparatus while boiling is spread upon a roadway prepared to receive it. The workmen must aim not to cover the surface as with a carpet, by spreading on it a thick layer, but rather to cause the tar to penetrate the highway itself. The result depends upon proper preparation of the road surface and the careful spreading of the hot tar.

It is preferable to work upon a re-surfaced road or certainly one in good condition. All work must cease if the ground be cold or damp. A heedless spectator might be delighted with the first aspect of his work upon a damp surface, as the pitch would promptly form a smooth carpet. Such work scarcely lasts through one summer, however, and goes to pieces with the first frosts. A thoroughly dried roadway must be taken, such as we have in July, August and September. From the surface every particle of dust must be removed. Ordinary mechanical sweepers are not proper for this task. Metallic-thread brooms are equally out of the question. We must have a sweeping material less hard than the road surface, in order to clean without breaking it. The pitch should be distributed from the center of the roadway. It should be poured, not sprinkled. The sprinkler is exactly the instrument which should be selected if the object were to chill the coal tar as quickly as possible. It is a very simple matter to pay out the pitch in small quantities and to spread it immediately upon the surface. The pitch penetrates well into the joints and impregnates thoroughly the whole roadbed. This process is aided by rubbing it in energetically with stiff brooms, which open the joints and conduct the pitch. One must not be disquieted by the rough aspect of the road surface—after several days it becomes united, compact and resistant. A very little sand, or even dust, thrown over the surface five hours after the dosing of tar completes the operation.

I have tarred roads for eight years, and have followed the above method for four years. My tarred roads last twice as long as those not so treated. The wear is imperceptible, especially during the first years. Certainly tarred roads do wear and need maintenance, and in my pamphlet I have set forth the conditions of this maintenance. According to material composing the roadway and other conditions, the economy resulting from the tarring of roads varies from 25 to 40%. Inexperienced persons usually begin by spreading a great deal of pitch, thinking to get better results. In reality they expend their money to obtain an ephemeral success.

*Some remarks of Road Commissioner Girardeau, of Fontenay-le-Compte (Vendée), quoted by United States Consul-General Skinner at Marseilles.

RIVER AND HARBOR WORK for 1905 will call for the expenditure of about $30,320,000, while about $10,000,000 will be required for the maintenance and extension of coast defense works, according to the estimates submitted by the Chief of Engineers, Gen. Alexander Mackenzie, in his annual report to the Secretary of War. Of the amount for River and Harbor work, $8,412,000 is for work carried on under the continuing contract system.

A MUNICIPAL MUSEUM is proposed at Chicago, and it is expected that the nucleus of this will be formed by a collection of gifts from American and foreign exhibits at the St. Louis Exhibition. Street cleaning and garbage disposal apparatus, the development of water front property for commercial and public uses, street construction, smoke prevention, and methods of municipal administration, would be among the important subjects. There are numerous exhibits of this kind, accompanied by statistical matter, reports, photographs and drawings, and the collection of these as a part of one comprehensive municipal museum would be a matter of professional and public interest and importance. It is anticipated that many exhibits will be donated for the purpose, and it is proposed to raise a fund for the purchase of others.

A FIRE AND WATER TEST OF DYNAMOS was successfully passed by three generators in the New England Bldg., Cleveland, O., a short time ago. A fire occurred in the basement, where the generators were installed. The insulation on the outside of the field coils was burned away completely and later the machines were thoroughly wetted by having the fire department play water on them. The dynamos were of 62½-KW. capacity and were direct driven by steam engines. Within an hour after the hose streams were turned off one of the machines was in operation again, carrying its full rating; later one of the other machines was put into operation and the two machines carried the load normally divided among the three. The field insulation was fireproof and was not damaged after the outer covering burned off. The accident is a good exhibition of the resisting qualities of modern electric generators. The information, which comes to us from the Westinghouse Electric & Mfg. Co. of Pittsburg, Pa., makers of the generators, does not mention the behavior of the engines, but it seems as if these must have been subjected to an equally severe test as the dynamos and apparently with complete success.

A LARGE STAND-PIPE AT SANFORD, ME., failed on Nov. 17. It was the property of the Sanford Light & Water Co. and had been in use only a few weeks. The upper half of the structure was thrown in one direction and the lower half in the opposite direction.

A WOOD WATER TANK AT WALTHAM, MASS., failed on Nov. 15. The tank was located at the foundry of the Davis & Farnum Manufacturing Co. We are indebted to Mr. F. H. Brown, Superintendent and Treasurer of the company, for the following information regarding the tank and its failure: The tank was erected in 1899 by a contracting company with large experience in tank construction. It was a tapering tank, 12½ ft. in diameter at the base, 11 ft. 5 ins. high, and was provided with nine flat bands, about ⅛ × 3 ins., all of the same size and uniformly spaced from top to bottom. Although the tank was kept well painted all the bands were corroded on their inner side, in some cases the thickness having been reduced to not more than 1/32-in. In replacing the tank twelve ⅝-in. round rods, with malleable iron connections, will be used. Mr. Brown is confident that had rods been used originally the failure would not have occurred, since so small a portion of the area of rods are in contact with a tank, and thus liable to rapid corrosion from moisture and from lack of protection by repainting. The steel pipe tower which supported the tank does not seem to have been injured by the failure of the tank.

EXPERIMENTS WITH COPPER AS A GERMICIDE have been made by Dr. S. Rideal, of London, and Mr. E. Baines, and were presented before the recent Congress of the Sanitary Institute at Glasgow. The experiments were suggested by the recent bulletin on "Copper Sulphate as a Method of Preventing Algae Growth in Reservoirs," issued by the United States Department of Agriculture last spring (see Eng. News, May 26, 1904). In the British experiments, pieces of copper foil were placed in flasks filled with a sterilized water, and the flasks were inoculated with cultures of typhoid, coli and other bacteria. The experimenters state that their work was only preliminary, but seemed to warrant the conclusion that the exposure of contaminated water in clean copper vessels for less than 24 hours would render the water safe for drinking purposes.

UNIFORMITY OF STANDARD METHODS FOR THE bacterial examination of water were recently reported by a committee of the Royal Institute of Public Health. Among the members of the committee were the following: Prof. Rubert Boyce, Chairman; Maj. W. H. Horrocks; Prof. G. Sims Woodhead; Prof. R. Tanner Hewlett, Honorary Secretary. All the members of the committee agreed that the minimum of procedure should include a bacterial count, and also a search for bacillus coli, with identification and enumeration if found present. The majority of the committee suggested two counts of all bacteria, with different methods of incubation and temperature, and also a search for and count of all streptococci. The report contains detailed suggestions for culture media and its preparation, and all of the technic of examination. The report is printed in full in the London journal, called "Water," for Oct. 15, 1904.

A VALUATION OF THE PROPERTY of the various gas companies in and near Boston has been made for the Massachusetts Board of Gas and Electric Light Commissioners, in accordance with the gas consolidation bill passed by the Massachusetts Legislature of 1903. This bill authorized the Boston Consolidated Gas Co. to take over the properties of eight companies at the fair value of the plants and properties, excluding franchise value, earning capacity and good will. The act limited the capital stock of the consolidated company to the valuation on the above named basis, less any indebtedness of the constituent companies which should be assumed by the consolidated company. The total valuation of the eight companies was $23,058,973, of which $2,782,375 was for real estate. Excluding real estate, the $20,276,598 of valuation was divided as follows: Buildings, $3,239,008; machinery, $5,072,737; mains, meters, etc., $11,964,833. Under "machinery" there was included $833,704 worth of electrical plant forming part of the Brookline company. Under "mains, meters, etc.," services and gas stoves were included. The valuations, except of real estate, were made by Mr. C. J. R. Humphreys, of Humphreys & Glasgow, 31 Nassau St., New York City, and were based on the replacement values of the plants.